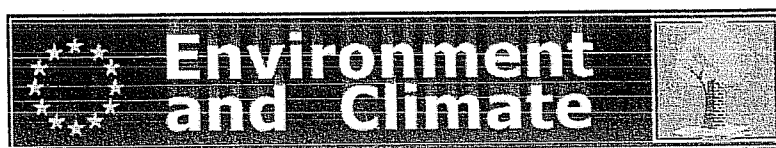# Industrial Energy Efficiency Policies: Understanding Success and Failure

Workshop organized by International Network for Energy Demand Analysis in the Industrial Sector

Utrecht, The Netherlands   June 11-12, 1998
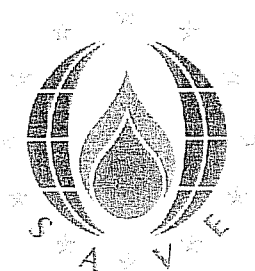
Environment and Climate

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Industrial Energy Efficiency Policies: Understanding Success and Failure

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Acknowledgements

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Workshop Summary

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1 Background and Introduction

Estimating the impacts of industrial efficiency policies and programs will play an increasingly important role for many countries as they develop plans to reduce carbon dioxide (CO_2) and other emissions. In order to develop a better understanding of such policies, it is important to improve international capabilities in this area through the use of expert networks. A network that has formed in recent years—the International Network for Energy Demand Analysis: Industrial Sector (INEDIS)—was formed for this purpose: to help bring together expertise to analyze industrial energy demand trends, policies, and programs.

On June 11-12th, Utrecht University, on behalf of INEDIS hosted a workshop entitled "Industrial Energy Efficiency Policies: Understanding Success and Failure." This workshop, sponsored by the European Commission (Directorate General XII's "Enrich" program and Directorate General XVII's "SAVE" program) brought together industrial energy experts from 14 industrialized and developing countries to improve the common understanding of the analysis and evaluation of industrial energy efficiency policies. The workshop grew out of earlier efforts to develop a common methodology for evaluating industrial energy efficiency trends in various countries, and, in particular, to find ways to better link the impact of particular efficiency policies to observed changes in the overall level of energy use and energy intensity[1]. In particular, *the workshop aimed to exchange country specific data and results of industrial energy efficiency policies, identify synergies between various policies, and compare evaluation methods*. Through the collaborative effort of a network of experts the workshop aimed to lay the groundwork for furthering understanding and building consensus on how to move beyond cross-country comparison using overall efficiency indicators to cross-country comparison and evaluation of specific efficiency policies.

This document provides: 1) a summary of the proceedings, 2) a synthesis of key lessons learned and main workshop conclusions, 3) complete text of all of the papers presented during the workshop, 4) a workshop agenda (Appendix A), and 4) a list of contact and reference information for workshop participants (Appendix B). The workshop was divided into sessions which focused on the evaluation of specific policy instruments such as financial instruments, voluntary agreements, information, monitoring, and research and development programs, (and technology-oriented polices as well as discussion evaluating integrated policies. There were also presentations

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[1] Earlier efforts in this area included: a 1994 workshop in Berkeley, California on international energy efficiency comparisons (Martin et al., 1994), a 1996 workshop in Vancouver, British Columbia on energy efficiency comparison methodologies for the industrial sector (Phylipsen et al., 1996), a handbook on methodology for energy efficiency comparisons in the industrial sector (Phylipsen et al., 1998), and work at Lawrence Berkeley National Laboratory to develop a common database of key industrial sector energy demand data that can be used by industrial analysts participating in the INEDIS network (Martin et al., 1998).

on industrial efficiency experiences from countries that are not members of the Organization for Economic Cooperation and Development (OECD).

2 Summary of Sessions

2.1 Financial Instruments

Two financial instruments were discussed during the workshop: a tax credit for energy efficiency investments in the Netherlands (Farla and Blok) and an evaluation of the Danish government's use of carbon dioxide taxes within a voluntary agreements scheme with their industrial sector (Togeby et al.).

The analysis by Farla of the "energy bonus" tax credit covered the period of 1980-1988. The program provided for a general investment credit of 12% and an additional bonus tax credit of 10-20% (depending on the year) for investments in energy-efficient technologies and sustainable energy. Over the whole period $3 billion was invested with 14% on average given as tax credit on investments. The most cost-effective efficiency investments tended to be in insulation while combined heat and power (cogeneration) appeared less cost-effective. There appeared to be no real distinction in payback periods between small versus large investments, but rather most of the quick payback investments (two years or less) were captured in the early years of the program. These high payback investments also accounted for most of the energy savings. While investments from the bonus program were a very small part of total investments, the energy savings from these investments accounted for over 50% of the total energy savings during the period.

The CO_2 tax program in Denmark was analyzed before and after the introduction of taxes. Industrial taxes were introduced gradually, and companies had the option to negotiate agreements (singly or as a group) and pay lower taxes. Fuels are taxed by end-use categories—light processes, space heating, and heavy processes use. General electricity use taxes are typically 25% while general coal use taxes are 90%. The highest taxes are for "comfort heating" (>100%). Taxes on heavy processes vary for electricity (1-20%) and coal (30-50%). Analysis results indicate that companies are indeed sensitive to energy prices with a price elasticity of –0.4 calculated for the period. Additionally, analysis of electricity consumption found that companies with a high amount of electricity consumption per unit output (electricity-intensive) reacted more to price changes than average, with price elasticities of –0.6.

2.2 Voluntary Agreements

Voluntary agreements for energy efficiency in the industrial sector can vary significantly from country to country. These agreements are often seen as a way to avoid more direct regulation to achieve similar national goals. A recent review by the International Energy Agency found more than 200 voluntary agreements enacted with industry in OECD countries (Newman). The agreements that were most successful were those which were transparent (e.g. with clear targets), credible, and consistently applied over time.

More detailed analyses of the Dutch long-term voluntary agreements were presented (Rietbergen et al., Nuijen). This program is currently unique in its comprehensiveness and stringency. Agreements were established with 29 industrial sectors covering 90% of industrial energy use for the period of 1989-2000. These sectors agreed to achieve on average an efficiency improvement of about 2% per year, or roughly double the rate of autonomous efficiency improvement.

Efficiency was defined based on an energy efficiency index where 1990 equaled 100. For industries evaluated in the mid-term analysis (1989-1995), most achieved the goal with an average efficiency improvement of 1.7% per year, slightly less than the 2%/year target. Cumulative investments required to operate the program (and provide training and technical support) were around $250 million but were found to be more effective at achieving incremental CO_2 reductions when compared to the investment tax credits discussed above. (Several different methods were used to evaluate the effectiveness of the voluntary agreements, and these are discussed in further detail in the lessons learned section.)

Future agreements (2000-2010) are targeting a slightly higher rate of efficiency improvement (2.2%). It was felt that there was a need to increase the rate of improvement in the new target to ensure credibility also to account for increased economic growth. These agreements will not only include energy efficiency improvement that involves new technology development, process synthesis, feedstock reduction, internal logistics optimization, and waste reduction, but will include other elements such as: stimulating product efficiency (dematerialization, renewable materials, low energy product design, new product technology) and industrial cooperation (recycling, chain management-measures along a total product chain, transport optimization, sustainable industry areas) reflecting an increasing focus on the end-use of the product in addition to the product manufacturing process. In addition to the voluntary agreements, a new investment tax credit will be instituted as well with energy efficiency investments that have an internal rate of return of 15% or above will be able to qualify for the credit. Current estimates by the Dutch government suggest that about 340 PJ of energy savings are achievable with the new framework, with energy efficiency accounting for slightly less than half the projected savings (160 PJ).

2.3 Information, Monitoring and Research, Development and Demonstration (RD&D) Programs

Information and monitoring programs are often established to help remove information barriers within industries to implementation of energy efficiency technologies or measures within industries. The workshop sessions presented program results from the US Industrial Assessment Center program (Muller and Barnish), Norway's Industrial Network for Energy Conservation (Finden), and the United Kingdom's Energy Efficiency Best Practice Program (Goult).

The Industrial Assessment Centers (IACs) are located in 30 universities in the United States. Graduate students from the IACs visit small and medium sized facilities (those with $75 million/year or less gross sales and $1.75 million/year or less energy bills), undertake an integrated energy and waste audit, and make recommendations for cost-effective energy savings and waste minimization/pollution prevention. Follow-up reviews are done to assess how many of the recommended options were implemented. All assessments since 1981 have been put on a database (over 7,700) which can be accessed electronically and used for a bottom-up evaluation of the program's effectiveness. Measures that have rapid paybacks of a year or less are the ones that have mostly been implemented, with implementation dropping off with longer paybacks. Overall, the IAC program has recommended more than $287 million of energy savings and $229 million of non-energy savings. About 42% of measures are implemented with historical savings averaging around $20,000/per project per year. In Fiscal Year 1996 however, savings averaged more than $31,000.

The Norwegian Industry's Industrial Energy Efficiency Network (IEEN) was started in 1989 and was designed to encourage energy efficiency activity in small and medium sized enterprises. The network currently has 500 companies enrolled which account for 70% of industrial energy use. The main activities include: information and motivation (annual report, newsletter, tailor-made

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seminars), energy management and analysis support (consulting assistance, monitoring equipment support, technical analysis support), technology demonstration, sector studies, and benchmarking on specific energy consumption. Agreements are made with industry associations. Industries that join the network agree to submit annual production and energy use information. Overall energy intensity for industry has dropped by 1.4% per year between 1994 and 1997 but no specific results of the IEEN energy savings were presented. Many companies, including energy-intensive manufacturers such as aluminum producers, have found that the energy benchmarking information provided by the IEEN is very useful and have sought out membership in the network.

The United Kingdom's Energy Efficiency Best Practice Program run by the Energy Technology Support Unit (ETSU) is an information exchange program. The program aims to stimulate energy savings by providing objective information to address limited understanding of efficiency technologies and helping to overcome market or institutional barriers to energy efficiency implementation. The program has a target of 140 PJ cumulative primary energy savings for the year 2000, and seeks to achieve energy savings equivalent to five times the program investment. Targets are set in consultation with industry representatives to identify all cost-effective measures (a 2-year payback or less) that can be implemented in the market. The program provides direct (and indirect) exposure to decision makers through publications and case studies of best practice methods, and energy consumption guides. Featured technologies and practices are both sector-specific (e.g. steel measures) and cross-sectoral (e.g. motors). Some of the largest savings have been achieved in the chemicals, paper, and food manufacturing sectors. The program may move towards the implementation of voluntary agreements in the future.

2.4   Technology-Oriented Policies

Two technology-oriented programs that were discussed at the workshop were the Netherland's efforts to promote combined heat and power (CHP) (Blok and Farla) and the U.S. Motor Challenge program to promote energy-efficient motors and motor systems (Scheihing et al.).

Unlike other European countries that have low levels of CHP in their generation mix, the Netherlands managed to increase the share of electricity produced by CHP to 23% of total electricity generation by 1993. The growth was due in part to national policies that were established as part of the National Environmental Policy Plan (and later policies) to promote CHP as a carbon emissions reduction strategy. National goals have been set for installed CHP capacity to increase to about 5000 MW installed capacity for 2000. Policies were analyzed in two periods, from 1978 to 1987 and from 1987 to the present. The first period included investment grants and credits, grants for feasibility studies, reduced grid charges, cheap contracts or tariffs for standby power, increased buy-back tariffs, open access, a small R&D program. During this early period electricity prices were relatively high making CHP investments more attractive. Analysis found that the investment grants and the increasing standby power buyback tariffs played the strongest role in promoting CHP, especially for small and medium facilities. For large facilities, policy intervention halved payback times to 4-5 years but this was still not economically attractive to promote large-scale investment. Since 1987, several new policies further increased the incentives for building CHP including establishment of a CHP bureau (a brokering and information agency) and increased subsidies for CHP construction. Since 1991 a voluntary agreement with utilities stimulated them to start joint ventures with industries and other partners for new CHP projects. The VA and joint ventures have been the main driver for CHP expansion since. Even though realizable CHP production with attractive payback times was limited, there is a virtual over-capacity today due to the historical stimulus. It was estimated that this stimulus accounted for roughly 90% of growth beyond business-as-usual CHP construction. Overall, the policy experience in the Netherlands suggests that while there was probably an overabundance of

policies used to achieve the goal of increasing CHP, policies became more refined and targeted over time.

The U.S. Office of Industrial Technologies, U.S. Department of Energy, developed the Motor Challenge program to gather stakeholders of a particular market and provide tools and information to help promote energy efficiency in motor systems. The goal of the program is to provide a network of resources (including MotorMaster+ software) to provide information to capture motor system efficiencies. The program goal is to capture 9 billion kWh savings by 2010. Industrial motor-system electricity consumption was 24% of all U.S. electricity sold in 1994. Most of the motor energy is consumed in pump systems (27%), followed by material processing (24%), and air compression (18%). Most motor system savings can be found with optimization and improved controls on pumps, fans, and compressed air with only a quarter of savings estimated from more efficient motors themselves. A recent market assessment found that 35% of the motor energy use is in less than 2% of the physical plants (large plants), particularly in the chemicals, paper, mining, and steel sectors. The research also found that most motor-system related purchase decisions are made at the plant level, and the level of knowledge of efficient motor systems is low. This research has helped the program to better target opportunities and leverage program resources. A recent evaluation of 13 showcase case studies found average energy savings of 33% with 1.5 year payback times. Energy savings opportunities are highly concentrated in industry and in particular end uses. These savings account for 1-10% of company operating margins depending on the sector. By focusing on key energy-intensive industries, the program hopes to better maximize savings opportunities.

2.5   Integrated Policies

In addition to the technology specific policies noted above, there are also integrated policies that promote industrial energy efficiency across various instruments. A presentation on industrial demand-side management (DSM) programs (de Almeida and Fonseca) discussed how the successful programs include good marketing, tailoring the programs to meet different customers, technical assistance, simple procedures and materials, financial incentives, and efficiency services for multiple end-uses. A particularly successful program discussed was BC Hydro's motor market transformation that spurred the regional market to adopt efficient motors through a combination of incentives and legislation. A similar integrated system of policies is required to modify the motor market in Europe, especially to overcome the lack of incentives that original equipment manufacturers (OEMs) have to improve efficiency for small motors. Such policies could include labeling, procurement, utility programs, voluntary standards, and information programs.

In the case of small and medium enterprises (SMEs) in light industry, the presentation (Ramesohl) argued for a more cyclic and dynamic understanding of policy implementation reflecting the fact that firms constantly face a challenge of optimizing all costs of production (not only energy). It was noted that successful implementation of energy efficiency projects first involved a key event that pushed the enterprise to be aware of efficiency, followed by decision-making and initiation of the projects, to finally their realization. In addition, mechanisms were established to evaluate existing progress and ensure continuity for continued investment. The initiation of this process is not always driven by energy concerns but could be an internal stimulus (e.g. broken equipment) or the result of some external stimulus (e.g. marketing by an equipment manufacturer). The success of these phases of implementation depend on a variety of factors including corporate culture, key staff involvement (to initiate and implement projects), management commitment, and a structure that incorporates project feedback. An integrated policy mix is needed to cover the whole implementation process. SMEs that are most successful in sustaining lasting efficiency investment are those that integrate efficiency in day-to-day company processes and those that are

linked to other companies and networks where they can get up-to-date knowledge of efficiency opportunities. (Ramesohl noted that informal networks are often coincidental or missing with SMEs, while British experience found that the SMEs often have strong contact with their local banks which is a useful area for promoting efficiency support). No one instrument is good for all companies and situations; rather different policies appear to be effective with different company types (e.g. those that have high-level management commitment versus those which have strong technical capacity to implement efficiency but little high-level commitment).

In the European Union, strong coordination will be needed with EU-wide industrial initiatives and national initiatives to best promote industrial efficiency. A presentation by Directorate General DG-XVII (Hagen) noted several EU activities to promote efficiency. In the area of Industry the DG-XVII strategy calls for doubling current electricity production in the EU by combined heat and power from 9% to 18% by 2010. The main policy tool in this will be financing support for CHP projects. Additional areas of focus will be support for the promotion of long-term agreements with industry. The goal of the strategy is to achieve reductions of 90 MtCO$_2$ and 35 Mt CO$_2$ for heavy and light industry, respectively, by 2010.

2.6   Experience From Non-OECD Countries

The implementation of industrial energy efficiency policies in non-OECD countries can often be difficult due to more uncertain macroeconomic environments. In the case of Russia (Bashmakov), one of the world's most energy-intensive economies, a very limited scope of efficiency activities has existed. Industrial energy intensity has increased in recent years (55% between 1990 and 1997) even with the 26% decline in industrial production. (The intensity of ferrous metals production, a more competitive sector, grew more slowly than average). This increase in intensity can be attributed to several factors including: shifts toward a more energy-intensive economy, inefficient capacity utilization, aging technology, low levels of investment, low status of energy efficiency in companies used to cheap energy supplies, and limited institutional frameworks to promote efficiency investment. While energy prices have risen dramatically in recent years due to economic reforms, these increases did not motivate energy efficiency investments (but rather non-payment of utility bills) because enterprises did not have access to capital markets. The rapid rise in prices outpaced the ability of industry to adjust and improve efficiency. However, there have also been some recent positive movements. One particular example is the planned implementation of a $480 million efficiency program between 1998 and 2001 at the Magnitogorsk steelworks. The plant has already reduced energy consumption per tonne of crude steel by 20% from 1996 to 1998. The Center for Energy Efficiency in Russia also helped to create the Russian Energy Managers Association (REMA) that is increasing knowledge of efficient practices and technologies and helping to promote efficiency policies.

Brazil (Schaeffer) has experienced a dramatic growth in electricity production averaging 8% annually between 1970 and 1990, with Brazil's industrial sector accounting for about 50% of the country's electricity consumption. The country's manufacturing sector contains a high share of energy-intensive industries that produced raw materials and semi-finished products for export. These export industries account for the largest share of industrial electricity consumption with embodied electricity in exports jumping from 5% in 1970 to 30% in 1994. Additionally, the share of electricity use has been increasing in these same energy-intensive industries. The PROCEL program, established in 1985, has been very active in implementing electricity efficiency projects (mainly motors projects in the industrial sector) and its 1998 budget is estimated at $100 million. The program has achieved cumulative savings of 2400 GWh/year in electricity use, with nearly a third due to industrial sector projects (lighting, meters, motors). However, even given these efforts, there exists a significant potential to reduce electricity consumption using a variety of

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policy instruments. Motor systems alone account for half of industrial electricity use and high-efficiency motors only account for 1% of all three-phase induction motors sold domestically mainly due to their higher first cost. Other barriers to efficiency investment in general include: decades of economic instability and high inflation, closed markets and lack of competition, ignorance of conservation measures and practices, immature energy efficiency infrastructure, low electricity prices, lack of capital, and lack of financial incentives for DSM programs. Several policy instruments could be applied to improve efficiency.

In India, industrial energy efficiency programs have lacked a long-term unified strategy and approach (Pal). Indian industry consumes about half of the country's commercial energy and there is great potential for efficiency improvements. In terms of national activities, the Energy Management Center was established in 1989 and there was a program in place by the Petroleum Conservation Research Association for several years starting in 1982 to provide low-interest loans for boiler modernization. Other successful financial incentives have included the allowance for full depreciation in the first year for conservation equipment (very popular for industry) and reducing customs fees for particular technologies. It was noted, however, that the list of allowable efficient equipment is hard to modify quickly and therefore one may miss out on capturing the full conservation benefits of newly developed technologies. A recent project being sponsored by the Asian Development Bank will support concessional loans for efficient industrial technologies in specific sectors. Some information and monitoring programs exist—especially for small-scale industries, and energy audits for large industries are mandatory in some states for companies that use more than 500 KVA/year. Research and development capacity for India in heavy industry is limited, and the country has tended to rely on imported technology. Additional information (including labeling or standards) and institution and capacity building is needed in India to better allow for the delivery of efficiency services.

3   Lessons Learned in Various Policy Evaluations

3.1   Need for a Credible Baseline

One of the most important issues raised during the workshop was how to properly establish a baseline of what would have happened in absence of the specific policy or groups of policies. The first aspect of this "baselining" involves getting a thorough understanding of the existing state of the sector before the policy is applied, and may involve ex-ante evaluations in order to compare the policy's impact. This step is followed by efforts to compare what would have happened without the policy in place, compared to what actually happened after the policy was implemented. This second stage often involves ex-post evaluation, modeling, or both.

⊕ In the study of the impact of tax credits for the Netherlands a simple investment model was used to estimate the autonomous efficiency gains expected during the period of the policy. The model, based on a survey of industrial consumers, assumed that low payback period investments would be implemented without additional incentives. (This approach does not explicitly account for any knowledge gaps investors may have on implementing low payback measures). The model suggested a high amount of free-riders (more than 85%) for the investment tax credit since most of the efficiency options were short payback.

⊕ In the study of the CO_2 tax in Denmark, detailed econometric modeling using a large data set of companies (about 3,000) was used to estimate price elasticities (by sector) and determine policy impacts with and without the tax.

● Canada uses a simulation model (ISTUM) to estimate autonomous efficiency and runs three simulations: frozen efficiency, autonomous efficiency (including price effects from fuel price changes), and autonomous efficiency with frozen prices. These three runs allow one to dissaggregate autonomous efficiency change, fuel price induced change, and then to analyze the impact of a policy or even model the expected impact of a policy. Discount rate and probability distribution surrounding technologies are main behavioral criteria used to simulate changes in purchasing behavior.

● In the US Motor Challenge program, detailed bottom-up market surveys were conducted to establish an accurate baseline of the current distribution and use of various types of motors and motor systems so that program impact could be more accurately assessed.

● In the case of analyzing the impact of voluntary agreements in the Netherlands, three different assessment methods were used, but it was still difficult to distinguish effect of voluntary agreements compared to the effect of other instruments, and to determine the business-as-usual trends without the policy. One method (bottom-up method) allocated measures into various investment categories (good housekeeping, replacement investments, etc.) and assigned the degree of stimulation that can be achieved by a voluntary agreement to calculate the "stimulated" savings. A second method applied historical autonomous efficiency improvement within the sector and compared the results to the voluntary agreement. A third method used a detailed technology database (ICARUS) to estimate the cost-effective investment and compared this to what would have occurred using the same investment model along with the investment tax credit.

● The IAC program in the U.S. conducts a follow-up evaluation of each audited facility to determine which measures of those recommended were implemented. This detailed information is then collected and entered into one large program database that is publicly accessible.

● The Best Practice program in the UK uses an investment model that assumes that efficient technologies will penetrate the market according to a traditional "S" curve. The impact of the program is then estimated as to how much the program was able to accelerate the natural penetration of the technology before it reaches market saturation (a shift to an advanced S-curve). Impact evaluation methodologies include both top-down and bottom-up assessments of best practice technology users through market surveys as well as data collection of sales of specific technologies. Surveys collect information on energy consumption and technologies adopted and are used to extrapolate sector-wide savings and assess the influence of the program. Establishing the market penetration of new products or technologies can be difficult, especially when the product is replacing an existing process or is designed as an alternative process. Future work for the evaluation of the program will focus on improving the attribution of program influence on actual energy savings, and improving estimates of the persistence of energy efficiency savings.

These evaluation approaches to determine a credible baseline can be grouped into top-down approaches (a mix of policies) versus bottom-up, often technology-specific approaches (e.g. efficient motor penetration). A participant noted that micro level programs require bottom up evaluation methods, including surveying people who received or did not receive the service. But, larger macro-level programs are ones that are candidates for top-down evaluation methods. Bottom-up evaluations are by their nature more detailed and often allow for a more precise calculation of baseline effects. Experience for the U.S. Environmental Protection Agency has been to match evaluation approaches to the particular program. Their Energy Star homes program is evaluated via a survey, while their industrial sector voluntary agreements have relied on data collected by the EPA or provided by a third party.

3.2　Which Evaluation Tools to Use?

As the proceeding discussion has shown, several evaluation approaches and tools exist. While participants did not recommend a specific tool, there was discussion about the strengths and weaknesses of different tools. For example, while both Germany and the Netherlands have voluntary agreements established with their industrial sectors, the evaluation procedure used in the Netherlands was more rigorous and was able to better isolate autonomous efficiency improvement. However, even in this case, the Dutch program evaluations called for additional modeling in baseline calculations, improvement in the monitoring of energy savings, more timely reporting by participating companies, and more rapid response to exclude non-performing companies from the agreements. (Companies that do not participate in the voluntary agreements have additional steps required to obtain environmental permitting).

Evaluation methods can be improved over time, and long-term program continuity is important in ensuring improved and higher quality evaluations. Also, methods need to be found which shorten the time between the application of measures and acquiring data on measure impacts. One participant argued that since the new policy environments of many countries involve the application of several policies at once, the partial deconstruction and evaluation of policy instruments could be the wrong approach.

Participants suggested that including comparison groups or control groups in evaluation are important to allow for a better calculation of the baseline. There was some consensus on the desire to use a variety of evaluation methods to evaluate policy impacts (as was done for example with the voluntary agreements' analysis in the Netherlands). It was not clear whether evaluation tools can be designed to separate the effects of individual instruments for policies integrating various instruments.

Of considerable difficulty evaluating is whether the program itself raised awareness and changed behavior even with non-participants. In the case of the CO_2 tax in Denmark, an additional voluntary energy agreements program for some companies did not appear to have any additional effect on increasing overall conservation. Corporate environmental standards such as ISO 14000 or Environmental Management and Auditing Scheme (EMAS) may also institutionalize energy efficiency decision-making as part of company policy and thereby capture additional savings.

Clearly, additional work is needed to refine our understanding of evaluation instruments. Some key research needs identified were:
- Refinement of methodologies to establish a baseline
- Measuring autonomous technical progress, structural change at the micro and macro level
- Developing firsthand knowledge on the use of correlation analysis (statistical methods)
- Strengthening the link between micro-evaluation and macro-economic evaluation instruments
- Approaches and methodologies to evaluate a mix of instruments and multipurpose instruments
- Improve ways to estimate the cost of evaluation (this is closely linked to transaction costs for a policy or program).

3.3   Evaluation Cost

There is a cost to estimating an accurate business-as-usual baseline, whether this is in developing appropriate models or conducting evaluation surveys. Various programs differed in their evaluation costs. The experience of voluntary programs in the Netherlands suggested that at least 10% of program cost are needed for administration and evaluation while experience in the ETSU program suggested less than this amount. The U.S. Motor Challenge program conducted a large market survey to establish a program baseline (an "up-front" cost of greater than 10% of program costs) but will probably have much lower evaluation expenditures in future years. A study commissioned by the International Energy Agency on demand-side management programs found that program evaluation was effective at improving program efficiency when costs did not exceed 7-8% of program costs. However, at higher evaluation costs than eight percent, one risks making the programs not cost-effective.

Some participants argued that hindsight evaluations are often much more expensive, and that thorough evaluation should be included in the initial plans. Furthermore, governments often lose interest in conducting thorough evaluations, especially for programs that are being phased out—as one participant noted, they are "yesterday's snow." However, the Dutch voluntary agreements program addressed evaluation mid-way through the program suggesting that it was more important to start action, get experience, and then design the program evaluation. If possible, pilot programs are useful for establishing appropriate evaluation procedures, but not all programs are set up this way.

The cost of evaluation can also be affected by the degree of cooperation from the participating industries. If industries have incentives to provide information—either because they want to ensure that their progress is being shown fairly or because the program results will provide them useful information—then they will more likely play an active role. This was the case with the Norway that found that many companies wanted to sign up with their industrial efficiency network given the useful benchmarking information they learned. Also, experience in the IAC program also suggested that when the scope of the policy was changed from just energy conservation to include waste minimization, pollution prevention, and productivity enhancements, there was increased management interest and attention.

Finally, evaluation costs can also be affected by whether one is evaluating an individual policy or program or whether one is evaluating an integrated set of policies designed to achieve a particular goal. The latter is often more difficult and costly.

3.4   Which Policy Instruments Appear to be More Effective?

The discussion of policy instruments first focused on policy goals. Some instruments are used to simply accelerate the penetration of efficiency technologies in the existing market (often short-term) while other instruments seek to transform the market to expand the potential or the frontier for efficiency technologies. Based on this discussion, a simple matrix (Table 1) was developed that categorized into those that rely on economic incentives to achieve efficiency versus those that rely on information and monitoring, and whether they are short term or primarily long term instruments (Table 1). Most policies (and the instruments used) aim to create a sustained long-term effect on the energy efficiency market.

Table 1. Policy instruments according to lifetime of measure (short term or long term) and economic/non-economic

3.5 Short term – economic	3.6 Short term – non-economic
Subsidies (audits, hardware):	Voluntary agreements/negotiated agreements
Tax schemes, rebates, credits	Information (audits, dissemination)
Regulation	Monitoring
3.7 Long term – economic	3.8 Long term – non-economic
R&D subsidies	Education and training
Pricing/taxation	Voluntary/Negotiated Agreements → transformation
Regulation	Strategy (corporate) change
Institutional change	Management schemes

Participants agreed that the success of a measure or instrument is dependent not only on the instrument itself, but the environment in which it is applied. They noted that the development of successful policies requires several factors: a strong human infrastructure development among policy makers, a good understanding of investment decision-making in industry, continuity in the implementation of a policy, common interests and effective communication between the stakeholders, and more intangibly, a strong desire by implementers to "market" the policy and achieve successful outcomes. Companies that are brought in to help determine the outcomes of a policy (e.g. how much efficiency to achieve) will have more of a vested interest in the policy's success and may even begin processes to change awareness internally to achieve these goals. Building in ex-ante evaluation will also, in many cases, ensure a more precise evaluation of the program's impact. Policies that account for the impact not just on efficiency but on overall profitability will have better chances of success.

There was not a consensus about which instrument was most effective. Often more than one instrument has been used at the same time. One participant noted that the use of economic or non-economic instruments depends upon the target sector, such as whether one is trying to achieve energy efficiency in heavy or light industry.

Another participant noted that certain instruments and policies (e.g. information programs) could be sustained for longer periods of time. For example, the benchmarking element of the Norwegian industrial efficiency network represents less than 5% of program expenditures but is popular with companies because it provides very useful information, and therefore there is interest in sustaining the program.

Many of the instruments that were discussed were voluntary. Voluntary instruments can often increase flexibility by industries on how they choose to achieve a target rather than having to comply with regulation, and may help to get a policy implemented more quickly. There are, however, pros and cons to this approach. In the United Kingdom, participation in the best practice program is voluntary; this creates difficulties because there is not enough participation often to collect adequate data to understand structural changes in the industry and establish a more accurate baseline. Participation in the Dutch long-term agreements is also voluntary and has succeeded in some part due to the good trust and working relationships developed with industries. However, incentives for the long-term agreements are structured so that it may be more costly to not participate (e.g. access to investment subsidies and simplified environmental permitting procedures).

4 Workshop Conclusions

The main conclusions from the workshop were:

- There is no single instrument to promote industrial energy efficiency improvement efficiently and effectively across all sectors and stakeholders. The reality is that often several instruments may be used simultaneously in an integrated approach. This reality requires analytical approaches that allow for the evaluation of both individual and integrated policies. Further research is needed in this area.

- When designing policies, the timing and objective of the policy (i.e. whether one wants to achieve the goal in the short term or long term) will help to identify what types and mixes of policy instruments would be expected to yield the best result. Short term policies aimed at achieving a certain improvement in energy efficiency in industry tend to rely on specific fiscal instruments (e.g. taxes, investment incentives) or specific institutional arrangements (e.g. voluntary agreements, information and monitoring systems). Such policies may seek to "piggy back" efficiency investment onto other profit making activities (e.g. promote energy efficiency investments based on non-energy benefits that improve overall production efficiency and reduce waste). Long-term policies often seek to transform the behavior of firms to adopt new and innovative operating practices that better "internalize" energy efficiency. These long-term approaches tend to rely on promoting investment in advanced technologies and the transformation of human capacity through education, training, and institution building.

- In the long-term, the achievement of energy efficiency in the industrial sector will work best when it efficiency considerations and investment are integrated into the day to day decision-making process at the firm, thereby reducing the amount of direct policy stimulus.

- Effective policy evaluation requires the establishment of a credible baseline that helps policy makers understand what would have happened in the absence of the implementation of the policy or measures. However, approaches for baselining differ depending on the resources availalable and specific policy measure. In many cases there is a need for both ex-ante and ex-post evaluation of policies. While the workshop has identified several evaluation methods, further efforts are needed to compare methods and identify the strenghts and weaknesses of various methodological approaches.

- Often, national data on changes in energy use are not carefully disagregated. Therefore, careful analytical approaches are needed to identify the impact of specific policy measures on changes in national energy consumption. "Bottom-up" evaluation which often involves the collection of detailed technology data helps to better link policy changes to national trends. The trade-off is that the collection of such detailed data can be costly, especially if not designed into the original policy implementation framework.

5 Next Steps

Based on these conclusions, some of the main research themes and activities that have emerged from this workshop include:

- Increase INEDIS network cooperation on the construction of bottom-up simulation models to estimate autonomous efficiency change and policy impacts.
- Develop a better understanding of ex-ante and ex-post evaluation methodologies, especially as they relate to the establishment of business-as-usual baselines.
- Identify which combination of policy instruments have worked most effectively in various environments and why.
- Improve ways to estimate the cost of evaluation.

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"Beyond Indicators" - Industrial Energy Efficiency Polices: Understanding Success and Failure

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Background

Many problems surround the provision of sufficient energy to meet human needs and to fuel economic growth worldwide. Key environmental problems related to energy use are global (climate change, ozone depletion), regional (acidification of soil and water), local (smog, urban air quality, solid wastes, effluents and thermal pollution) or indoor air pollution. International policy documents like Agenda 21 and the Framework Convention on Climate Change (FCCC) underline the international recognition of the problem of climate change in particular. The most important human activity contributing to this problem is the production and consumption of energy from fossil fuels. Although there are uncertainties about the impact of human-induced climate change, many countries have agreed that responsive action should proceed and several European Union countries have implemented policies to reduce greenhouse gas (GHG) emissions through increasing energy efficiency and fuel switching.

The main factors affecting energy growth in an economy include the energy consumed per unit of economic activity, the size and structure of the economy (depending on consumption patterns and stage of development), and the rate of population growth. In many developing countries economic growth, increased industrialization, and expansion of population are rapidly overtaking efficiency improvements within the economy. The amount of energy consumed per unit of economic growth is affected by how efficiently energy is used to provide energy services in an economy, which can be improved by energy efficiency improvement. In the near and medium term, the most effective and feasible policies for restraining energy growth involve improving the efficient use of energy in all sectors (agriculture, industry, buildings, and transportation) and encouraging the shift to a less energy-intensive economic and industrial structure.

The workshop focuses on the industrial sector, as it is still the largest energy-consuming sector in the world (worldwide it consumes approximately 43% of primary energy demand and in the EU approx. 36%). Therefore, it is also responsible for an even larger share of CO_2 emissions (approximately 47%), and contributes likewise to other environmental damage. Industry contributes also to the emission of other greenhouse gases, i.e. methane (e.g. refining, ammonia production, nitrous oxides (e.g. fertilizer and nylon manufacture) and specific CFCs (e.g. primary aluminum production, production emissions from foam expanders and refrigerants). But, curiously, detailed knowledge on the industrial sector is often lacking in the public sector. Previous studies showed that data relating to industrial energy use, output, processes, technologies, and efficiency measures and policies were often incomplete or non-existent (especially for developing countries and countries with economies in transition). Rational programme design depends vitally on information that describes the processes and changes. The

INEDIS project is initiated to gather and analyse such information and to establish a more solid baseline and scenarios of industrial energy demand, all of which will be extremely useful for those concerned with international energy and greenhouse gas emission issues. It will help to understand trends in industrial energy use and CO_2 emissions, and to evaluate policies. This information will be needed in future work of many (inter)national organisations, e.g. for the IPCC, EU policy planning, OECD/IEA, and climate negotiations within the Conference of Parties. Formal contacts with some of these organisations are already established (i.e. IEA, IPCC).

The workshop is organised by the members of the International Network of Energy Demand Analysis in the Industrial Sector (INEDIS). INEDIS is formed by research groups from various countries, to strengthen the base for analysis and assessment of industrial energy use, as it was felt that public knowledge to understand the energy use patterns in this sector (being the largest global energy user) is lacking. The network tries to increase the understanding by data collection, trend analysis, policy evaluation and technology assessment. The network is sponsored by seed-funding of the European Commission (DG-XII) and Lawrence Berkeley National Lab (USA). This workshop is one of the first activities of the network and would help to develop tools to evaluate industrial energy efficiency policy, and to understand the critical factors in designing industrial energy policies. A detailed description of the background and objectives of the workshop is given below as an appendix to this letter. The workshop is sponsored by the European Commission through the SAVE Programme of DG-XVII, and the ENRICH Programme of DG-XII, as well as U.S. Department of Energy, Office of Industrial Technologies.

The institutes that initiated the INEDIS network and this workshop have previously worked on the development of international accepted methodologies for international comparisons of energy efficiency and energy efficiency developments. The INEDIS network and this workshop, have grown out of the experiences gained in this development work.

1   Indicators of Energy Efficiency

The development of methods to standardise the way we measure energy efficiency has significant implications for improving environmental quality, for bettering our understanding of how we use energy, and for helping countries and international organisations better evaluate their efforts to develop and promote energy efficiency policies. Since we are not in a time of great energy price instability (particularly after the Gulf war), there is little concern about energy security aside from the fact that some countries still face capital constraints for energy imports and infrastructure. So the real problem related to the promotion of energy efficiency is the link between energy production and use and environmental problems. Energy efficiency indicators will help us relate levels of emissions to energy end-uses in the home and at the office and factory. Only through careful measurement and the development of appropriate indicators can we tell if we are using more or less energy. One of the most prominent environmental concerns over the past years has been the potential rise in global warming due to the release of carbon dioxide and other greenhouse gases which contribute to rise in surface temperatures on the earth's surface. The international body tasked with assessing the current state of knowledge, the Intergovernmental Panel on Climate Change (IPCC), has a strong interest in promoting energy efficiency as a response strategy to mitigate the release of emissions. The promotion of energy efficiency investment is particularly important in the near and medium-term since other strategies such as reduction in population growth or reduction in economic growth are so politically difficult to enact. Changing energy prices, the evolution of technologies, and energy efficiency programs all contribute to changes in energy efficiency. In most OECD countries before 1973, technological change led to energy savings, as it reduced energy intensities in most competitive manufacturers

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and many transportation systems. In addition many economies experienced a large expansion of their service sectors which lowered overall intensity. After 1973, higher energy prices, and to a certain extent energy efficiency programs such as thermal standards on new buildings, efficiency standards on household appliances, and for the United States, Corporate Average Fuel Economy (CAFE) standards on new cars clearly led to changes in energy efficiency that would not have otherwise occurred except perhaps over a very long time. Unfortunately, the measurement of the effectiveness of energy end-use policies can be difficult, especially when one is attempting to forecast and prescribe effective policies over a 30 to 40 year time frame. What matters with programs is not only whether energy consumption has declined, but also whether the program has caused a sustained change in the patterns of energy consumption. For almost every end-use there are ways to technically save energy, but measuring the change in human behaviour is more difficult. To better evaluate program effectiveness we need to know more about the structure of energy demand, what new information to collect (i.e. the design of better survey instruments), and where to go to spend the resources to get the information we need. Individual countries as well as international organizations are interested in the question of program evaluation to better understand the permanence of savings. In a recent study on energy efficiency the International Energy Agency found that the biggest uncertainties in forecasting energy savings lie in predicting human and market behavior, and that current models need to incorporate detailed disaggregated data from regular monitoring of policies and market conditions. As will be discussed later, such data forms the backbone of energy efficiency indicators.

Which kind of energy do we measure? How do we normalize across countries? For example, some countries in Eastern Europe and the Commonwealth of Independent States (CIS) have experienced dramatic decreases in energy consumption; how much of the drop is due to structural changes in energy use and how much is the result of economic activity reduction? In terms of measurement one can also go into a very high level of detail and discover that energy use among a very homogeneous sample can vary by a factor of 2! When we can count energy usage how does one compare for differences across countries? For example, is it fair for Japan to reduce space heating when houses are generally smaller and cooler in Japan to begin with when compared to Europe? All of these are salient questions to the current environmental debate, especially when a country commits to serious emissions reductions as part of the Framework Convention on Climate Change.

To start to answer these questions a workshop was organized in March 1994 at Lawrence Berkeley National Laboratory on "International Comparisons of Energy Efficiency". The purpose of the workshop was to work towards reaching a broader international consensus on the type and use of indicators for measuring and comparing energy efficiency among countries. The meeting brought together experts from Europe, North America, Japan and Developing countries. Based on the workshop, the group concluded that many energy analysts routinely aggregate countries and regions in energy forecasts, even differences in economic structure and lifestyle exist. It is difficult to measure differences in efficiency from these intensity changes. The discussants were in agreement on the need for a common use of and methodology for developing indicators. They discussed the main issues and proposed suitable indicators per sector. Only continued strong cooperation and involvement by policy makers and research analysts in individual countries and international organizations, could help to bring more consensus on the best choice and use of indicators. Specific recommendations include:

- Develop an (informal) network of research analysts involved in the development and use of indicators;
- Pursue follow-up workshops in individual sectors;
- Develop a handbook on the measurement and comparison of energy efficiency, and on the

analysis of the potentials to improve energy efficiency

2   Indicators for Industrial Energy Use

As recommended at the Berkeley Workshop separate tracks for each of the economic sectors were followed. For the manufacturing industry a network of experts on industrial energy use was set up to discuss the development of methodologies for international comparisons of energy efficiency. A follow-up workshop was organized in Vancouver (Canada) in April 1996. The cooperation in the network and at the workshop resulted in a 'Handbook on International Comparisons of Energy Efficiency in the Manufacturing Sector', describing methodologies. At the same time efforts in the European Union and at the International Energy Agency further elaborated the work on indicators. A variety of publications since then have highlighted the use of indicators, resulting in e.g. a special issue of *Energy Policy* (June/July 1997). One paper analyzed the energy consumption developments of the iron and steel industry in seven countries for the period 1980 to 1991. It examined the trends in these countries and compared the energy efficiencies of steel production over time. Using a decomposition analysis based on physical indicators for production, it decomposed the changes over time to more carefully examine intra-sectoral structural changes, including the use of secondary steelmaking and efficiency improvements. The selected countries show varying trends, although the observed SEC decreased in almost all countries. Efficiency improvement played a key role in the observed energy savings in Brazil, China, Germany, and the U.S., while structural changes were the main driver for energy savings in France and Japan. Even though the structure became slightly less energy-intensive, energy efficiency decreased in Poland due to the economic restructuring process. Other sectors and countries were investigated in other papers, and a wide body of available literature since then. The question remains what part of the energy intensity changes and efficiency improvements are due to energy policies. Barriers to efficiency improvement can include: unwillingness to invest, lack of available and accessible information, economic disincentives, and organizational barriers. The degree in which a barrier limits efficiency improvement is strongly dependent on the situation of the actor. This means that no single instrument will 'do the job'. A range of policy instruments is available, and innovative approaches or combinations have been tried in some countries. Successful policy can contain regulation (e.g. product standards) and guidelines, economic instruments and incentives, voluntary agreements and actions, information, education and training, and research, development and demonstration policies. Successful polices with proven track records in several sectors include efficiency standards and codes, technology development, and utility/government programs and partnerships. But how effective and efficient were these policies and programmes? Effective energy policies need reliable data, and reliable assessment methodologies. In this workshop we will aim to address this issue.

3   Workshop Objectives

A wide variety of energy policies have been used in many countries, under different conditions. In the workshop this variety is visible, through the different policy instruments that will be discussed during these two days. Assessment of the effects and effectiveness of efficiency policies gets even more complicated when various instruments are used in parallel. The second day we will look into these complex issues. The objective of this international workshop is to establish common and accepted methodologies to analyze trends in energy efficiency and the effectiveness of energy policy instruments and policies in the industrial sector. To accomplish this, we will examine international experiences with industrial energy efficiency programs and policies.

The objectives of the workshop are:

- to exchange experiences and results of industrial energy efficiency policy evaluations;
- to develop a detailed understanding of industrial energy efficiency policies in various countries;
- to strengthen the international analytic capabilities for evaluating industrial energy efficiency policies, which can serve in particular as an input for national and international analyses;
- to design an internationally-accepted evaluation tool for industrial energy efficiency policies;
- to establish international cooperation of industrial energy efficiency policy specialists; and
- to improve the analytic capabilities of developing and Eastern European countries.

The primary function of the workshop is to bring together analysts that are specialists in the field of industrial energy use and policy. An important outcome of the workshop is the establishment of a collaborative network to analyze such information to gain a more solid understanding of the influence of industrial energy efficiency policies.

Specific outcomes of the workshop will be:

- compilation, exchange, and analysis of country-specific data on industrial energy efficiency policy experiences;
- identification and preliminary evaluation of policy areas and strategies to reduce the environmental impact of industrial activities by evaluating and comparing national activities and experiences;
- identification of synergies between environmental, economic and energy policies in the industrial sector to develop environmentally sustainable development paths;
- production of workshop proceedings outlining the major issues; and
- establishment of an on-going collaborative network, building on other international efforts, between interested parties in Europe, USA, and other countries.

This workshop does not stand alone. It builds on previous workshops. More importantly, the workshops built on the experiences of the experts present and co-operating in the event. The subject of this workshop is even more challenging than the previous workshops. I would like to encourage you to see the workshop as a beginning, rather than an end, in the same tradition as the previous two workshops.

Energy Conservation Investments of Firms:

Evaluation of the Energy Bonus in the Netherlands in the 1980's[*]

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Abstract

Energy efficiency improvements may be stimulated by several policy measures, like subsidies, energy taxes and standard setting. In this paper, one specific policy measure in the Netherlands is analysed: the *energy bonus*. The energy bonus was a large-scale subsidy scheme that existed between 1980 and 1988 for stimulating investments in energy efficiency improvement and renewable energy. The data on energy efficiency improvement have been analysed.

The total of subsidized investments in energy efficiency improvement amounted to 5.7 billion Dutch guilders[**] (Dfl), and the subsidies amounted to nearly 0.8 billion guilders (14% of investments). These subsidized investments led to an estimated annual energy savings of 130 PJ, and account for half the energy savings in Dutch firms in this period. The average specific investment costs are derived for 20 different energy conservation technology categories. The average specific investment costs ranged from Dfl 27 to Dfl 56 per annually saved GJ, for the different technology categories. From the total investment and savings figures we calculated an average weighted specific investment of 43 Dfl per GJ saved annually. The average pay-back periods, calculated with saved energy purchase costs and taking the subsidy into account, were under two years from 1980 to 1985, and rose considerably in the years thereafter. We did not encounter differences in profitability and specific investment costs between small and large investments.

The subsidy measure seemed to suffer from a considerable "free-rider effect". We estimate that over 85% of the energy savings would also have occurred without the investment subsidy. If we assume that the remaining 15% energy savings was stimulated by the subsidy, then the subsidy measure costed (to the government) approximately 40 Dfl per GJ of annual savings.

The estimated low efficiency of this subsidy scheme gives us the idea that a newly started subsidy scheme (since 1997) with widely the same characteristics may result in the same low efficiency.

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[*]Adapted from "Energy Conservation Investments of Firms: Analysis of Investments in Energy Efficiency in the Netherlands in the 1980's", presented at the 1995 ACEEE Summer Study on Energy Efficiency in Industry, Grand Island, NY, USA.
[**]1 Dutch guilder equals 0.5 U.S. Dollar (exchange rate at the beginning of 1990).

1   Introduction

Energy efficiency improvements may be stimulated by several policy instruments, like e.g. subsidies, energy taxes and standard setting. A large uncertainty still exists about effectivity and efficiency of the different instruments. In this paper, one specific policy measure in the Netherlands is analysed: the energy bonus in the *investment account act.*

Between 1980 and 1988 the energy bonus existed as an incentive for firms to invest in (a.o.) energy conservation. The energy bonus was part of the investment account act, a set of subsidy measures embedded in the income and corporate tax system. We used the data on the energy bonus to investigate the characteristics of investments in energy efficiency improvement, and to correlate the resulting energy savings with the total energy savings in the Netherlands in the same period.

Two objectives are addressed in this paper. In the first place, we characterize the investments in energy conservation that were subsidized, by investment costs and pay-back period. We give an estimate of the energy savings that resulted from these investments and relate these to the total energy savings that occurred in the same period in the Netherlands. In the second place, the effectiveness and efficiency of the energy bonus will be addressed.

This evaluation may also be of importance for the valuation of a newly launched energy efficiency instrument. In 1997 the Ministry of Economic Affairs introduced the "Energy investment tax relief scheme" (EIA). This subsidy instrument shows a striking similarity with the energy bonus that was abolished in 1988. Therefore, the results of our evaluation of the energy bonus may give us an idea of the effectiveness and efficiency of the energy investment tax relief scheme.

2   The Energy Bonus

2.1   General Description of the Energy Bonus

The first phase of the investment account act (IAA) was enacted on May 24th of 1978 (1). This first phase consisted of a general investment tax credit. This meant that firms could deduct a certain percentage of every investment from their corporate (or income) tax. On the 19th of July 1980, the energy bonus was enacted as part of the second phase of the investment account act. The second phase of the IAA was meant as an extra set of tax credits which were granted for desirable investments, like investments in energy conservation, in environmentally friendly processes and investments in specific regions of the country.

The IAA was meant to stimulate investments in general, and with it economic growth and employment. The energy bonus was meant to stimulate investments in energy conservation *over* other investments. Another reason for the energy bonus was that the high energy prices in those days were an increasing burden to trade and industry. Though these high energy prices made investments in energy conservation already more profitable the high energy prices had, according to the government, already decreased the firms' resources to invest, which seriously endangered the possibilities to carry out the necessary energy conservation programmes (2).

2.2 The Energy Bonus Procedure

Investments that could be subsidized with an energy bonus were described in a limitative list (the *energy list*). The energy bonus was granted to several categories of investment projects. The main categories that were distinguished were investments in:

A. insulation and improved heating of buildings
B. energy-efficient production equipment
C. combined heat and power
D. equipment to use heat derived from wastes
E. solar energy
F. wind energy
G. equipment for the use of coal as fuel
H. energy efficiency improvement of means of transportation
I. hydropower energy

A further division in subcategories is given in Appendix 1. The categories A, B and H aim at efficiency improvement of the end-use of energy. Investments in category C improve energy conversion efficiency, while the categories D through F, and I aim at stimulating the use of untapped and sustainable energy sources. Category G was meant to stimulate the use of coal, which in those days fitted in the governmental policy of diversification of the energy use in the Netherlands. In this analysis we focus our attention at investments in efficient energy conversion and end-use in firms. These are the categories A, B and C.

Investments in energy conservation that were described in the energy list were subsidized with a 10% investment tax credit. This bonus came on top of the general investment tax credit, which was between 12 and 13% for equipment. The energy list was adapted seven times between 1980 and 1988, mainly to include new energy conservation technologies. In the years 1982 and 1983[*], the bonus was temporarily increased to 20% to accelerate investments in energy efficiency.

In the energy list a distinction was made between two kinds of investments: investments for which a minimum energy conservation per invested guilder was applicable, and investments without such a limitation (cf. appendix 1). At the introduction of the energy bonus, the minimum energy conservation (for the selected subcategories) was 0.5 m^3 natural gas equivalents[**] (approximately 15.8 MJ)[***] per invested guilder. At January 1st 1983, the conservation requirement was lowered to 0.4 m^3 natural gas equivalents (approximately 12.7 MJ) per invested guilder. The reasons for lowering the conservation requirement were two-fold. The government reasoned that due to inflation the requirement had become more severe. Furthermore, the ongoing process of investing in energy conservation exhausts the very profitable energy conservation investments (3).

The investment categories without a minimum energy savings requirement were believed to at least achieve comparable annual savings, i.e. more than 0.4 m^3 natural gas equivalents per invested guilder (2). They were exempted from the requirement because verification was difficult for these investment categories (2).

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[*]Investments that were taken into operation after January 31st of 1982 and before January 1st 1984.
[**]For calculation of the conservation requirement the following conversion factors were used: 1 kWh of electricity = 0.34 m^3 natural gas equivalent (nge); 1 tonne of coal = 925 m^3 nge; 1 tonne heavy fuel oil = 1300 m^3 nge; and 1000 litres of light fuel oil = 1200 m^3 nge (2).
[***]Throughout this study we applied the lower heating value of Groningen natural gas (31.65 MJ/m^3) to convert one m^3 of natural gas equivalent to heat values.

Furthermore, investments had to be above the investment limit of Dfl. 10,000 and a franchise of Dfl. 5,000 was regarded (meaning that Dfl. 5,000 was deducted from the investment before the energy bonus was calculated). The investment limit was lowered to Dfl. 5,000 in 1985. At the same time, the franchise was abolished. It should be noted here that firms could also apply for the energy bonus if their investments were not done with the *objective* to save energy. The only restrictions were that the investment had to be awarded a general investment credit, had to be in the energy list, and that (if applicable) the energy conservation requirement was met. This implies that firms replacing old and worn equipment could also be granted an energy bonus.

Application for the energy bonus was due within three months after the goods were taken into use. Applications for the energy bonus were handled by the *investment account department*. There the investment category of the investment was attributed, and the investment amount itself was assessed. Only the part of an investment that was *relevant* for the energy savings was taken into account. For instance, "fancy tilework was not considered necessary for energy conservation in a building that was built around a CHP installation" (4). The investment account department also assessed the energy savings requirement. If the requirements were fulfilled the investment account department gave a declaration to the investor with which the tax reduction could be asked for. Because of the described procedure, it generally took more than one year between the actual investments and the tax reduction. Especially for large investments with a long installation or building period the time lapse could even be several years. The time frame for an investment that was subsidized with an energy bonus is depicted in Figure 1. An important date in the time frame is the date on which financial obligations were made. With this date it was decided which amount of energy bonus (10 or 20% of the investment) was attributed.
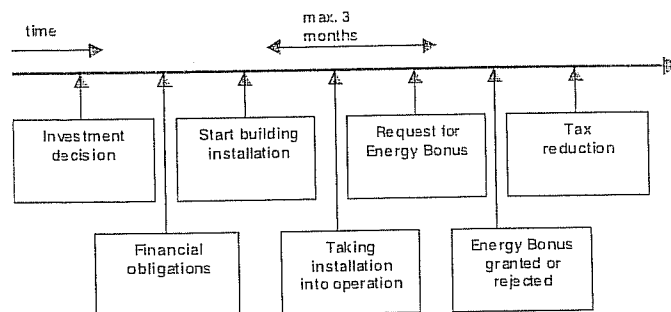
Figure 1. Time frame for the Energy Bonus

2.3   Evaluation of the Energy Bonus

Before we turn to the available data on the energy bonus, and the analysis of these data, we describe briefly a background of the analysis.

The energy bonus was granted for investments for which a financial obligation was made between 1980 and 1988 (cf. Figure 1). In a large part of this period (1981-1985), the energy prices in the Netherlands were the highest since the second World War. Furthermore, the first years of the 1980's were years of economic recession. The energy bonus should, of course, be analysed with these backgrounds in mind.

An investment subsidy may be called 'effective' when the subsidy is a condition without which the desired investment would not have occurred. This implies that we have to find out which investments would have occurred without an energy bonus. To this end we make a distinction between two types of energy conserving investments:

- add-on investments
- replacement investments

With add-on investments we indicate (mostly small) investments in goods that come 'on top' of the existing equipment. These investments may be done mainly for the sake of energy conservation, or with other intentions but with an energy saving effect. Examples of such add-on investments are a.o. insulation, heat recuperation, automatic controls. A larger investment in this category is e.g. investment in combined heat and power. With replacement investments we indicate the substitution of old equipment with new equipment. Because of technological progress the new equipment can be more energy efficient than the substituted piece of equipment. We assume that adoption of add-on investments is governed mainly by the profitability of the specific investment, and that the replacement investments are mainly governed by the lifetime and age of equipment.

The profitability of an investment (in energy efficiency) can be expressed with several economic variables. In industry the simple pay-back period is often used as investment criterion, sometimes together with other investment criteria (5-8). In this analysis we also used the pay-back period, based on saved energy purchase costs, to indicate the profitability.

3 Methodology

3.1 Data on the Energy Bonus

Two sets of data were available for the analysis: annual statistics (9) and an electronic database (10). In the annual statistics, the number of approved requests is given, as well as the matching figures for the 'relevant' investments, the energy bonuses and the expected energy savings. These data are given per investment category and per year in which the investment was granted. These statistics concern 26298 investments.

The second set of data consists of an electronic database that was kept by the investment account department starting (gradually) in 1982 (10). Because the start of the digital database lies two years behind the introduction of the energy bonus, the database is far from complete. We used the electronic database for calculations, and the annual statistic data for verification and extrapolation purposes.

The data in the electronic database had to be cleared and adjusted before we could use them. The original electronic database contained 20,071 records. First we removed the approximately 5,000 'doubles' from the database. Investments were inserted 'double' when the subsidy on one investment had to be shared between several owners of a partnership. After removal of the doubles we had to remove some incomplete records. For 72 records no investment category (cf. appendix 1) was included. For 496 records no investment figure was included. We then removed all the records concerning an investment category greater than 20 (because only the main categories A, B and C are analysed). This left us with 12,759 records, which included at least data on the investment category, the investment and the energy bonus.

Sometimes an applicant objected against the decision of rejection or against the part of the

investment that was considered 'relevant' for the energy bonus. The figures after appeal are taken instead of the initial figures for investment and bonus. The 'energy bonus relevant' investment figures were reconstructed with the energy bonus figures. This energy bonus was either 10 or 20% of the relevant investment, depending on the year of investment.

Of the 12,759 records, only 2,611 records contained data on the projected energy savings of the investment. This implies that the electronic data that we can use for calculating profitability constitute approximately 10% of the total number of investments.

3.2   Calculation of Pay-back Periods

For 2,611 records in the electronic database we were able to calculate an energy-related pay-back period. To this end we calculated the annual saved energy purchase costs by multiplying the energy savings with the energy costs. The annual savings are reported in m^3 of natural gas equivalents. It is not clear which energy carrier was saved in a specific investment project. Because most investment categories of the energy bonus relate to heat savings we chose the natural gas price for our calculations (natural gas is the most important fuel for heating purposes in the Netherlands). For savings on coal and oil this may lead to too short calculated pay-back periods. For savings in electricity it may lead to too long calculated pay-back periods. Energy costs were derived from EnergieNed (11). We took the natural gas price for large consumers*. The natural gas prices that were used in calculating the PBP's are given in Table 1.

Table 1. Energy prices used for the calculation of pay-back periods

Year	Energy price (Dfl/m^3 nge)
1980	0.28
1981-1983	0.40
1984-1985	0.45
1986	0.26
1987	0.21
1988-1992	0.19

A simple pay-back period was calculated by dividing the initial investment by the annual saved energy purchase costs. Because all investments were also granted the general investment tax credit (12-13%), we took this credit into account. The tax credit was given after taxes. The actual (financial) benefit is therefore larger than with a normal subsidy. On the other hand, the time lag between the actual investments and the tax deduction reduces this difference (if a discounted cash flow method is used). For reasons of simplicity, and in order to link up with the easiness of the PBP criterion, we chose the following formula to calculate the pay-back periods:

$$PBP_i = \frac{Inv_r \times (1 - \{IC_g + IC_{eb}\})}{ES_a \times EP_{ng,i}}$$

With: PBP_i = the pay-back period for a good that was taken into operation in year i; Inv_r = relevant investment; IC_g = general investment credit (we used 12.5%); IC_{eb} = energy bonus (10 or 20%); ES_a = annual energy savings; and $EP_{ng,i}$ = the energy price (for natural gas) in year i.

The pay-back period was calculated with and without taking the energy bonus into account to determine the profitability effect of the energy bonus in terms of a shorter PBP. It should be noted

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*Consumers with an annual consumption of 10-50 million m^3 natural gas annually.

that our calculated PBP's are energy-related PBP's. Other costs (e.g. increased operation and maintenance costs) and benefits (e.g. labour cost reduction) are not taken into account. Therefore, the calculated PBP only gives a limited insight in the actual profitability of the investment.

4 Results

4.1 Investments and Energy Savings

Between 1980 and the end of 1990 an energy bonus declaration was given for 26,298 investments. The investments involved amounted to 6.23 billion Dutch guilders, and the energy bonus amounted to 0.88 billion guilders (9). These figures imply that an average energy bonus of 14% of the investment costs was granted. The number of requests per year, and the number of granted energy bonuses per year are depicted in Figure 2. We can see from this figure that it took some time between the application for the energy bonus and the granting of the energy bonus. The requests that were done after termination of the subsidy measure in 1988 relate to projects that were already started before the end of the energy bonus program. From Figure 2 we can also see that it took some time before investors started to send in requests for the energy bonus. After 1985 a decrease in the number of requests can be seen. This may possibly be explained by the large decrease in energy prices after 1985. In Figure 3, the investments that were granted an energy bonus are related to the total investments by firms. From this figure we see that the subsidized investments in energy efficiency improvement constitute only a very small part of the total investments.
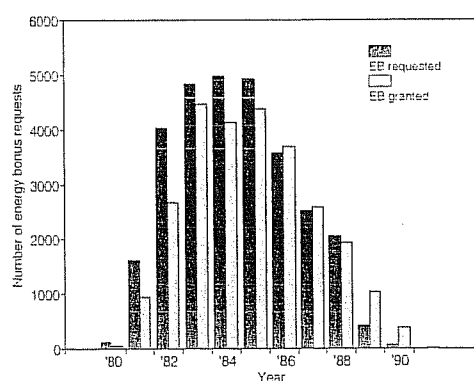
Figure 2. Number of requests for the energy bonus per year, and number of granted energy bonuses.
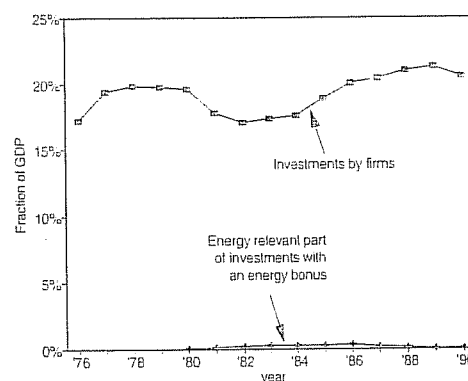
Figure 3. Total and energy bonus investments by firms, related to the gross domestic product.

The investment projects that were granted an energy bonus are given in Table 2 per investment category. From Table 2 we see that 96% of number of investments and nearly 91% of the invested money relate to energy efficiency (categories 1-20). In Table 2 we also give the projected energy savings as assessed by the investment account department. Together with our own estimates for the categories for which the energy savings were not given (figures in italic in Table 2), we arrive at a total of energy savings of 132 PJ annually. With the results from a previous study (12) we can correlate these energy savings to the total energy savings in this period. The primary energy consumption in the Netherlands (except residential and transport) decreased with approximately

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250 PJ (net), between 1980 and 1988, when taking only efficiency improvements into account. This means that about 50% of the (net) energy savings in the Netherlands (excluding residential and transport energy use) can be attributed to investments in energy efficiency that were granted an energy bonus.

The remaining energy efficiency improvement may be caused in part by operational changes requiring no major investment (good housekeeping). Another part may be explained by investments that were not granted an energy bonus, including investments for which no application for an energy bonus was made, and investments that were not eligible for the energy bonus (e.g. investment smaller than the investment limit).

4.1   Characterization of Investments in Energy Efficiency

With the data in the electronic database we were able to divide the investments in size classes according to the amount of money invested. The total investments, savings and number of investments are depicted in Figure 4.

From this figure we can see clearly that the larger investments make up for the largest part of the savings. Furthermore, we found that the specific investment and profitability (PBP) do not differ significantly among the different investment size classes.

With the data on the energy bonus we are able to characterize the investments that lead to energy efficiency improvement. For thirteen investment categories full energy saving data were available (see Table 2).

The ratio of the total investment and energy savings per category corresponds to the weighted mean specific investment[*], expressed in guilders per GJ saved annually. These figures are also reported in Table 2. For seven investment categories no full information on the energy savings was available. For these categories, a specific investment figure was introduced with which the total energy savings per category were calculated. The specific investment for the categories 1 and 17 were derived from the electronic database. The specific investment figure for the categories 2 and 8 was derived from the database ICARUS (13), a database with over 800 energy conservation measures for a large number of sectors in the Netherlands. For the 'heat pump' categories (3 and 7) we introduced a specific investment of 80 Dfl/GJ$_a$[*]. Finally, the specific investment in combined heat and power production (investment category 20) is calculated with an average investment of 1500 Dfl/kW, 7000 running hours per year, and a national power generating efficiency of 40%.

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[*]Because we used the totals of investment and savings, the specific investment figure is 'weighted' with the size of the investment; large investments have a larger weight in calculating the mean value.

[*] This figure is the highest specific investment that fits in the conservation requirement of 0.4 m^3 per invested guilder. The figures in ICARUS(13) suggest that the specific investment figure for heat pumps is higher (approximately 110 Dfl/GJ$_a$). However, this difference will only have a minor influence on the total energy savings because of the relatively low investments in these categories (see table 2).

Table 2. *Overview of investments and energy savings per investment category.*

Investment category	Nr. of investments (nr)	(%)	Amount of investments total (10³ Dfl)	(%)	average (10³ Dfl)	Savings (PJ)	Sp. Inv. weighted (Dfl/GJa)	(nr)*	Sp. Invest. unweighted (Dfl/GJa)	St. dev. (Dfl/GJa)
1. building insulation	21279	80.9	1109 057	17.8	52	*27.7*	*40.0*	1280	44.2	21.1
2. waste heat/space heating	33	0.1	2997	0.0	91	*0.1*	*40.0*	-	-	-
3. heat pumps/space heating	189	0.7	20 913	0.3	111	*0.3*	*80.0*	-	-	-
4. heat pumps/space heating	355	1.3	78 274	1.3	220	5.1	15.2	123	26.6	19.4
5. equipment insulation	184	0.7	60 044	1.0	326	2.3	25.9	79	27.0	19.9
6. control measures	819	3.1	329 938	5.3	403	14.3	23.1	262	32.7	20.5
7. heat recovery	75	0.3	36 371	0.6	485	*0.5*	*80.0*	-	-	-
8. heat pumps/prod. equipment	13	0.0	64 622	1.0	4 971	*1.6*	*40.0*	-	-	-
9. waste heat/prod. equipment	32	0.1	50 227	0.8	1 570	2.0	25.4	14	28.7	18.7
10. power recovery	364	1.4	175 344	2.8	482	6.1	28.7	103	34.6	22.8
11. improved firing	237	0.9	836 233	13.4	3 528	16.9	49.4	112	37.1	23.9
12. evaporation/distillation	251	1.0	140 911	2.3	561	2.6	53.7	96	56.1	17.9
13. drying equipment	169	0.6	46 451	0.7	275	0.9	49.9	74	43.8	18.3
14. cooling/sterilization	185	0.7	598 116	9.6	3 233	11.7	51.3	79	50.8	21.1
15. melting/kilns	4	0.0	25 069	0.4	6 267	0.7	35.6	1	36.2	-
16. electrochemical equipment	58	0.2	4 638	0.1	80	0.1	36.1	18	44.9	19.3
17. electric./fuel switch	229	0.9	200 041	3.2	874	*5.2*	*38.3*	45	38.6	21.9
18. drives/transformers	112	0.4	41 581	0.7	371	1.9	22.1	65	30.7	21.6
19. vacuum pumps	32	0.1	58 467	0.9	1 827	1.4	40.5	23	46.4	24.5
20. computer control	619	2.4	1777 556	28.5	2 872	*29.6*	*60.0*	1	33.3	-
21. combined heat and power	342	1.3	71 470	1.1	209					
22. waste combustion	30	0.1	16 020	0.3	534					
23. adapt. waste combustion	34	0.1	30 351	0.5	893					
24. waste fermentation	76	0.3	3 044	0.0	40					
25. solar collector	167	0.6	21 931	0.4	131					
26. wind energy	280	1.1	269 052	4.3	961					
27. coal as fuel	0	0.0	-	0.0	-					
28. coal gasification	25	0.1	157 363	2.5	6 295					
29. efficiency aircraft	63	0.2	4 500	0.1	71					
30. efficiency ships	42	0.2	410	0.0	10					
31. wind guide trucks	0	0.0	-	0.0	-					
water power energy										
Totals	26298	100.0	6230 995	100.0	237	131.1	43.1			
Totals Cat. 1-20	25239	96.0	5656 853	90.8						

The figures in bold italic are estimated (see main text). The last three rows are derived from the electronic database [10], while the other figures are from the annual statistics [9]

* number of investments used for calculation of the unweighted specific investment and standard deviation.

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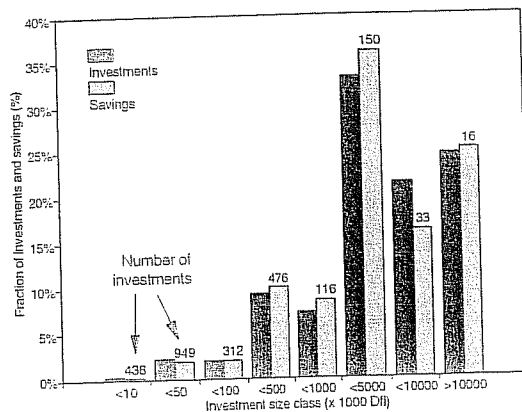
Figure 4. Investments and savings per investment size class (as fraction of the total).

The weighted average investments show a large variation between the different categories, ranging from Dfl. 52,000 for insulation measures to over Dfl. 6 million for improvement or replacement of electrochemical and metallurgical equipment. From the total investments (cat. 1-20) and total savings we calculated a weighted specific investment of 43 Dfl/GJ_a. We also calculated the average (unweighted) specific investments with the electronic database. These are also reported in Table 2, together with the sample standard deviation. The average specific investments range between 27 and 56 Dfl/GJ_a. The standard deviations are all in the order of 20 Dfl/GJ_a.

With the formula in the previous section we calculated the pay-back periods for the 2611 investments in the electronic database. These calculations were performed with and without taking the energy bonus into account. These are depicted in Figure 5, after ordering the investments according to increasing pay-back period. From Figure 5 we see that 40% of the investments has a PBP of under 2 years. In Figure 6 the same data are plotted against the cumulative energy savings. This yields logically a different picture. Nearly 70% of the total savings resulted from investments with a PBP of under 2 years.
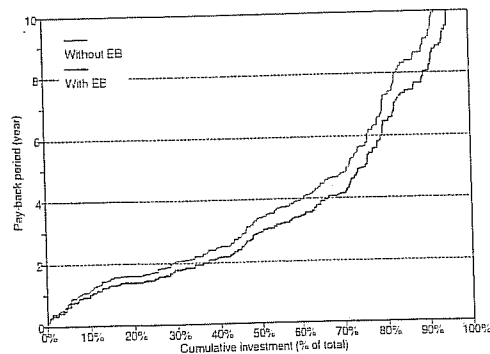
Figure 5. Pay-back periods related to the cumulative investment.
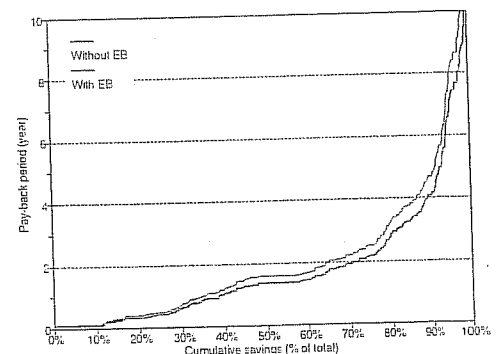
Figure 6. Pay-back periods related to cumulative savings.

4.3 Developments in Time

We calculated the average pay-back period per year from the specific investment figures and the gas price in that year. To calculate the PBP we also took the general investment credit and energy bonus into account. The development is depicted in Figure 7. From this figure we see that until 1985 the PBP's are under 2 years, and go up considerably afterwards. This may be partly explained by the high energy prices, which made investments more profitable until 1985. However, the data in Figure 7 indicate that also the specific investments became higher after 1985. Possible explanations for the increasing specific investment after 1985 are the following. In the first place, the ongoing process of investing in energy efficiency may have reduced the possibilities for very profitable investments in energy efficiency. In the second place, the increasing specific investment may have resulted from more risky (replacement) investments due to a growing confidence in the improving economy.

5 Effectiveness and Efficiency

5.1 Introduction

In the previous section, we saw that a large fraction of the energy savings resulting from the energy bonus investments had very low pay-back periods. This leads us to believe that a large fraction of these investments might also have occurred without the subsidy measure. In the following subsection we assess the effectiveness of the subsidy measure: what part of the investments is stimulated by the energy bonus. Furthermore we assess the efficiency: the ratio of costs and benefits of the measure.
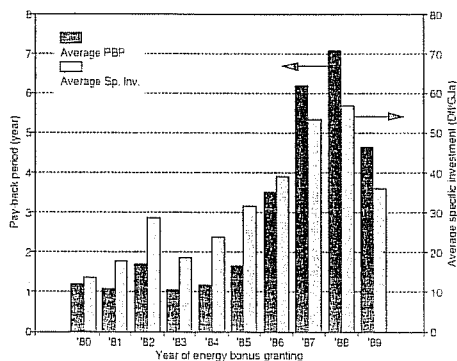
Figure 7. Development in time of the average PBP and the average specific investment.
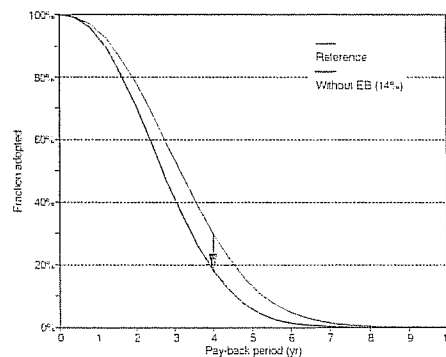
Figure 8. Modeled relation between adoption of an energy conservation measure and PBP.

5.2 Effectiveness

In this section we want to find out what part of the investments in energy conservation were induced by the energy bonus. Two *financial* effects can be attributed to the energy bonus: first, the bonus reduces the pay-back period of an investment, and secondly it lowers the amount of capital needed. The second effect is not taken into account because the investor had to invest the full amount of money in advance of getting the credits back.

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The effectiveness of the energy bonus is assessed with a simple investment model. This model indicates what part of the investments with a certain PBP would also have been carried out without the energy bonus. The profitability criteria of firms are have been generalized by Hein et al. (14), on the basis of studies by Gruber (6) and Koot (7). In Table 3 the cut-off pay-back periods are given. Table 3 indicates that e.g. 95% of the firms would adopt an energy-efficient technology with a PBP of 1 year. The data in Table 3 were interpolated for our calculations (14). The interpolated line is depicted in Figure 8. The other line in Figure 8 indicates the fraction of measures that would have been implemented if no energy bonus had been granted. We took the average value of the energy bonus of 14% for our calculations.

Table 3. Relation between PBP and adoption of energy conservation measures

Simple Pay-back period (year)	Adoption (% of technical potential)
1	95
2	80
3	55
4	30
5	10

From Figure 8 we can, for instance, see that for a pay-back period of 4 years 30% of the available measures will be implemented, whereas this would have been 18% if no energy bonus had been granted. We now set the total number of investments in our electronic database with a PBP of 4 years equal to the 30% in Figure 4. Then 60% (=18/30) of these investments would also have been carried out without an energy bonus, and we assume that the remaining 40% is stimulated by the energy bonus. By doing so for all investments, we can get an indication of the projects that would have happened without the energy bonus. The results are depicted in the Figures 9 and 10. The measures that would have been adopted without the energy bonus are indicated with `free-rider'.

It should be noted that the investments with a PBP higher than 7 years would, according to the model, not be implemented. It is possible that other reasons were responsible for these investments. These other reasons could have been that old equipment had to be replaced, or that large savings were possible on e.g. labour or material costs.
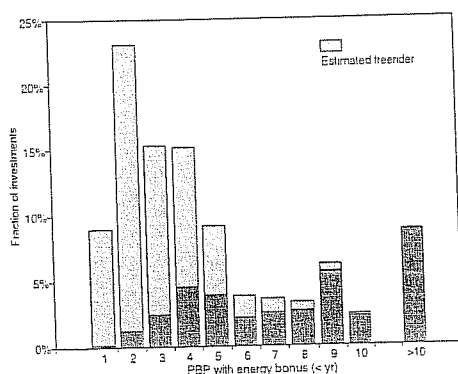
Figure 9. Estimate of the investments that were (not) stimulated by the energy bonus
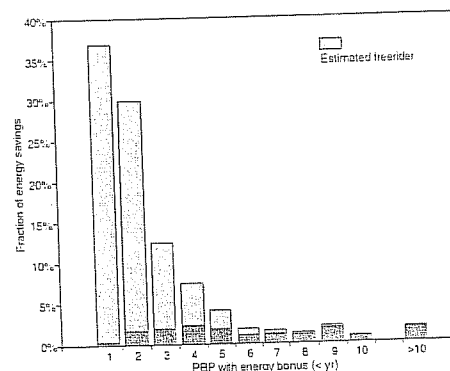
Figure 10. Estimate of the energy savings that were (not) stimulated by the energy bonus.

The fraction of the investments that is attributed to the free-rider effect in Figure 9 amounts to 64%. If we look at the energy savings related to these investments, the free-rider fraction increases to 85%. This is caused by the fact that the investments with a low PBP (logically) have a larger energy saving per invested guilder.

5.3 Efficiency

In this section we want to assess the ratio of benefits and costs of the energy bonus in the investment account act (as seen from the government point of view). We measure the benefits in the form of investments in energy conservation that were stimulated by the energy bonus, and the resulting energy savings. The costs are composed of the remitted energy bonuses and the organizational costs of the energy bonus.

The investments that were stimulated by the energy bonus (cf. Figure 9) amount to Dfl. 2 billion (36% of 5.7 billion). The annual energy savings related to these investments amount to 20 PJ. This is calculated with the 15% of the energy savings that would not have occurred without the energy bonus, and the total energy savings calculated previously to be approximately 130 PJ.

The costs related to the energy bonus can be split into the direct costs, and the indirect costs. With the direct costs we refer to the granted energy bonuses, estimated at Dfl. 0.8 billion (9). The indirect costs consist of the personnel costs related to designing and carrying out the measure. The number of man-years is estimated at 100-200 (15), which implies that the indirect costs are negligible (1-2%)[*] in relation to the direct costs.

Taking the above together, we arrive at 20 PJ of energy savings at a cost of Dfl. 0.8 billion. This implies the specific savings to be 40 Dfl per MJ of annual energy savings.

6 Comparison of the Energy Bonus and the Energy Investment Tax Relief Scheme

The Energy investment tax relief scheme was started January 1st, 1997. With this scheme the government again created a general subsidy scheme for investments in energy efficiency. Although there are some differences between the energy bonus and the energy investment tax relief scheme, the similarities prevail. Both schemes are embedded in the corporate or income tax system, and both schemes aim at stimulating investments in energy efficiency improvement. Also, in both schemes, the investment has to result in a reasonable energy saving per guilder invested. It is also interesting to see that the same organisation is responsible for the assessment of the applications to both subsidy schemes. The most important characteristics of both subsidy schemes are given in Table 4.

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[*]Based on annual hiring costs for personnel of Dfl. 80,000 per person.

Table 4. Characteristics of the Energy bonus and the Energy Investment tax relief scheme.

	Energy bonus	Energy investment tax relief
Period	July 19, 1980-January 1, 1988	January 1, 1997-today
Subsidy	10-20% after taxes	14-18% effectively, after taxes[a]
Investments subsidised	According to limitative list	According to limitative list
Investment criterion	0.5 m^3 nge/Hfl (until 31/12/'82) 0.4 m^3 nge/Hfl (after 1/1/'83)	0.5 m^3 nge/Hfl (large users)[b] 0.25 m^3 nge/Hfl (small users)[b]
Investment threshold	Hfl 10 000 per category	Hfl 1 000 per investment Hfl 3 600 per year
Investment limit	Hfl 5 000 franchise	Hfl 200 million per calendar yr
Application before	None	3 months after the start of financial obligations
Accountant statement	3 months after the installation was taken into operation necessary	necessary

[a] 40-52% of the investment can be deducted from the profit before taxes. We calculated with the 35% tax level for companies.
[b] Small energy users use less than 170 000 m^3 of natural gas per year and/or less than 100 000 kWh of electricity.

In the Energy investment tax relief scheme the subsidy is given before taxes, instead of after taxes with the Energy bonus. The Energy investment tax relief scheme will result in a subsidy of approximately 14% of the investment after taxes. In the Energy investment tax relief scheme the period of application has moved back in time, thus shortening the period in which the investor has to wait for his subsidy.

7   Discussion and Conclusions

The data on the energy bonus gave us the opportunity to investigate what kind of investments lead to the improvement of energy efficiency in firms. However, we should bear in mind the specific circumstances in the period in which the energy bonus existed. In the first place, the early 1980's were years of economic hardship in the Netherlands. The second oil shock had increased energy prices to the highest in the Netherlands since the Second World War. After 1985 these energy prices decreased, and the economic performance already began to grow in 1983-1984. Against these macro-economic developments, the energy bonus seems to have had only a limited impact on investments.

Unfortunately the data did not allow us to examine the energy savings per branch of industry. The total amount of savings could be compared with the net energy savings in the Netherlands in the same period. The subsidized investments are responsible for approximately 50% of the total energy savings in firms (including agriculture, excluding transport) between 1980 and 1988. We may conclude that only a very small part of the total investments in the Netherlands (namely these energy bonus subsidized investments) led to a large part of the savings in the observed period.

The data on the energy bonus allowed us to calculate an energy related pay-back period. These calculated PBP may in fact have been too high, because often other benefits can be attributed to new investments, e.g. product quality improvement, labour cost reduction and automation of the process (see e.g. Farla and Blok (16)). On the other hand, increases in maintenance and operation could also not be taken into account. We found a large amount of very profitable

energy efficiency investments. Especially in the early 1980's very low average PBP's are encountered. After 1985 the average specific investment rose. The decrease of energy prices contributed to the fact that the PBP's in those years were far higher. The figures also suggest that the increasing economic performance led to more (replacement) investments, not carried out for energy efficiency in the first place. This is supported by the overall increase of investments by firms after 1985.

No real differences were found between the different investments size classes. This means that, on average, both small and large investments showed the same specific investment costs and pay-back periods.

The very low PBP's encountered in the first years of the 1980's give us the idea that these investments would also have been carried out without the energy bonus. The impact of the energy bonus on the financial resources of a firm are believed to be low, because the firm had to invest the money a long time before the energy bonus could be deducted from the tax. The free-rider effect was examined with a simplified model, with which add-on investments are predicted. With this model we calculated large free-rider effects; we estimate that 85% of the energy savings would also have been carried out without the energy bonus. These free-riders consist of very profitable investments that were also profitable without the energy bonus. Besides these investments, investments with long PBP's may have been carried out for several other reasons besides energy conservation.

This leads us to the conclusion that the energy bonus seemed not very effective in stimulating investments in energy efficiency, and was therefore a very expensive (cost-ineffective) policy measure. We should, however, be careful with our judgement because financial incentives are not the only effects exerted by subsidy measures. Other effects of subsidy measures include the (implicit) governmental approval of the subsidized investments and the drawing of (management) attention to the subsidized measures. The effect of *accelerating* the adoption of energy-efficient technologies could also not be assessed. The energy bonus may have accelerated investment decisions, especially during the temporary increase of the bonus from 10 to 20% in the years 1982-1983.

At this moment only few data are available on the investments subsidized with the Energy investment tax relief scheme. We have seen that both schemes show a large similarity. It is therefore reasonable to expect that the Energy investment tax relief scheme may also show a low effectiveness and efficiency. This may be the more the case since many of the side-effects mentioned in the previous paragraph (governmental approval, management attention) may not occur as these are already triggered by government policies like the long-term agreements on energy efficiency.

8 Acknowledgements

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Appendix 1. Energy list: category division of efficiency measures that were eligible for an energy bonus under the investment account act

A. Investments for the benefit of improved insulation and heating of buildings, by
1. a) insulation of walls by cavity insulation
    b) insulation of walls by other means*
    c) insulation of roofs and floors*
    d) insulation of buildings by multiple glazing and double (window) frames
    e) insulation of greenhouses and warehouses by double skins/walls
    f) insulation of greenhouses and warehouses by movable screens
    g) insulation of equipment, piping and ducts of the climate control equipment*
    h) reduction of ventilation losses*
    i) improvement of control equipment for climate or lighting*
    j) heat recovery from flue and waste gases and process streams*
    k) efficiency improvement of heating equipment*
    l) total replacement of heating equipment*
    m) improvement of the heating equipment in greenhouses and warehouses**
    n) improvement of lighting in existing buildings*
2. using waste heat generated outside the firm, or by delivery of generated waste heat outside the firm*
3. heat pumps and related equipment*
B. Investments aimed at efficient energy consumption in production equipment, by
4. insulation of equipment*
5. improved production control*
6. heat recuperation*
7. heat pumps and related equipment
8. the use of waste heat generated outside the firm, or by delivery of generated waste heat outside the firm
9. the use of expansion energy*
10. improved firing equipment*
11. improvement or replacement of evaporation and distillation equipment*
12. improvement or replacement of drying equipment*
13. improvement or replacement of cooling equipment, and pasteurization and sterilization equipment*
14. improvement or replacement of melting equipment and kilns*
15. improvement or replacement of electrochemical and electro-metallurgic equipment*
16. replacement of electric heating (in the production process) by heating with fossil fuels*
17. replacement of electric drives and transformers with equipment with better matching capacities*
18. substitution of steam ejectors with vacuum pumps*
19. computer control of the production process*
C. Investments in combined heat and power
20. investments in installations for combined heat and power generation
D. Investments to use heat generated from the combustion of wastes, by
21. new installations for the combustion of waste*
22. adaptations to existing installations to make these suitable for waste combustion*
23. equipment for anaerobic fermentation of waste and for the burning of the fermentation gases*
E. Investments in equipment to use solar energy, by
24. the use of solar energy collectors
F. Investments in equipment to use wind energy, by
25. the use of wind turbines
G. Investments in equipment to use coal as a fuel, by
26. direct use of coal as a fuel
27. coal gasification
H. Investments in the energy-efficient use of means of transportation, by
28. the adaptation of existing aircraft*
29. the adaptation of existing ships*
30. detachable wind guide on trucks
I. Investments in equipment to use hydropower, by
31. the use of water turbines

* Categories for which a minimum energy conservation requirement was applicable
(** until January 1st, 1983).

Evaluation of the Danish CO_2 Taxes and Agreements

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1 Introduction

In 1993, Denmark introduced a CO_2 tax on trade (the service sector) and industry. In 1995, the Danish Parliament adopted a package of new measures in order to conform to the environmental targets concerning reduction of CO_2 and SO_2 emissions. Between 1996 and 2000 the CO_2 tax increases considerably, and a new SO_2 tax is introduced. In order to minimise negative effects on the competitiveness of energy intensive companies, the system allows for these companies to get a tax reduction if they enter an agreement on energy efficiency with the Danish Energy Agency (DEA). The system is described more in detail in section 2.

The Ministry of Finance expects the CO_2 package to reduce the CO_2 emissions from trade and industry by 4.6% of the total Danish CO_2 emissions in relation to the 1988 level by the year 2005 (Regeringen 1995).

In this paper evaluations of the agreements (section 3, 4, and 5) and the general tax are described (section 6). Different studies of the agreements indicate a positive impact of the activities, in the form of energy savings and increased activities in relation to energy management. But, also, that it is difficult for the authorities to influence the energy intensive companies: The authorities (and even consultants) have difficulties in establishing a detailed technical knowledge about the individual production processes. As a result the companies have a strong position when they discuss with DEA which concrete projects should be included in the agreement.

An econometric analysis of the electricity consumption in Danish industry shows that prices and taxes matter. This analysis is carried out on a micro panel database containing information about most Danish industrial companies. An average price elasticity of -0,41 has been found. The elasticity has been estimated for different sub-groups. The result is that the companies where electricity matters the most (high electricity intensity, high share of electricity compared to total energy consumption) have the strongest reaction to changes in prices.

2 A Multi-level Tax Scheme

The Danish CO_2 tax scheme is not coordinated with the other EU Member States. Therefore, the system is designed to protect the competitiveness of energy intensive companies and to minimize the redistribution between individual companies and between sectors. When the CO_2 package is fully phased in, the effective level of taxation will be the highest in the world for industry. The annual revenue derived from the tax is expected to be 0.5 billion ECU in year 2000 which is approximately 1% of the total state revenue. This revenue, however, is recycled—mainly by lowering the non-wage costs of labour. If the tax levied was a flat-rate tax, this arrangement could favour the labour intensive service sector, but this is counteracted

by a high tax on space heating and a low tax on certain energy intensive processes.

The level of taxation depends on the purpose of the energy use. Three types of energy use are defined. When companies use the same energy source for different purposes, several meters are required within the company. The three types of energy use are: space heating, light processes and heavy processes. Heavy processes comprise several energy intensive processes, e.g. melting, concentration and drying in relation to the production of cement, mineral wool, condensed milk, and sugar. In total, 35 processes have been defined as heavy processes. Heavy processes account for 61% of all energy used in *industry*. The remainder is divided between light processes (27%) and space heating (12%) (Danmarks Statistik 1997). In *trade and services* the energy use is divided between light processes and space heating.

The energy intensive companies will pay a low tax on heavy processes. Furthermore, a limited number of energy intensive companies may enter an agreement with the DEA. An agreement can lower the tax for heavy or light processes. The lowest tax in the absence of an agreement is 3.1 ECU per ton CO_2. However, with an agreement, it is only 0.4 ECU per ton CO_2. Table 1 shows the five different tax rates.

Table 1. CO_2 and energy tax by the year 2000, ECU per ton CO_2

100 ECU = 753 DKK	Space heating	Light processes	Heavy processes
Without agreement	79	12	3.1
With agreement	79	9.0	0.4

Source: Ministry of Finance 1995.

For each energy source the total tax is calculated from the content of energy, sulphur and carbon. In Table 2 both energy taxes and the CO_2 tax are included. The sulphur content varies with the fuels. Natural gas does not contain sulphur, so the values in Table 1 are the total tax for natural gas. Coal with 0.6% sulphur is subject to considerable sulphur taxes. This is illustrated in Table 2. For the lowest tax levels the sulphur tax dominates (94% of the total tax for heavy processes with an agreement).

Table 2. Total taxes (CO_2, energy and sulphur) for coal by the year 2000, ECU per ton CO_2

	Space heating	Light processes	Heavy processes
Without agreement	86	18	9.2
With agreement	86	15	6.4

Source: Ministry of Finance 1995.

2.1 Agreements

Companies with energy intensive processes can enter a three-year agreement with the DEA in order to qualify for a lower tax rate. After the three years the agreement must be renewed. Two kinds of agreements can be made: individual agreements and group agreements. Agreements can be made for both heavy and light processes. Whereas companies with heavy processes always have the right to enter an agreement with the DEA, companies with light processes are defined as energy intensive—and obtain this right—only if the calculated tax of the energy

consumption amounts to at least 3% of value added. It is another condition for entering an agreement that the calculated tax must exceed a certain minimum value. This condition excludes many small companies from the possibility of entering an agreement.

An agreement specifies several activities, which the individual company must undertake to qualify for the reduced tax rate. These activities can include a realisation of "profitable" energy-saving projects, introduction of energy management including energy accounting, motivation of staff and activities to ensure that investments in new equipment will be energy efficient. The basis for *individual agreements* is energy audits. An energy consultant or company staff can carry out the audit. Today, all audit reports must be verified by an independent certified organization.

In theory, all profitable energy savings are described in the audit report. Pay-back periods of up to 4-6 years (lowest for agreements concerning heavy processes) are considered profitable by the DEA. When no profitable energy savings are identified in the energy audit companies are considered energy efficient, and in consequence these companies need not carry out further investments in energy efficiency in order to obtain the reduced tax rate.

The *group agreements* are made with groups of companies from an industrial sub-sector with similar production processes. The idea is to reduce the administrative costs of entering an agreement. The group agreements are not based on energy audits performed in the individual companies. Instead, an analysis of energy consumption and production processes in the sector is made to identify general potentials for improving energy efficiency in the companies. The result of this analysis is reported to the DEA and used to formulate an action programme. Negotiations with DEA are conducted by the trade organisation, but each individual company has to sign—and is committed to—the action programme.

Companies with agreement must deliver a yearly progress report to the DEA. In this report the fulfillment of the agreement must be reported together with a status for the energy management. The Danish energy agreement system was initiated after and inspired by the Dutch system. In Togeby et al. (1998) the two systems are compared. The political background for the Danish system is described in Johannsen and Togeby (1998).

3   Evaluation of Agreements – Database

DEA maintain a database concerning companies with an agreement and the related savings (Ahé et al., 1998). Central aspects concerning the agreements are illustrated with figures from this database.

In 1996 and 1997, the DEA has made agreements with 92 industrial companies (plus 59 greenhouses). This is illustrated in Table 3. The number of companies entering into agreements is expected to increase to 200 industrial companies, when the economic incentive for an agreement increases over the next few years.

Table 3. Number of companies with agreements

Type of agreement	1996	1997	1998[1]
Heavy processes	21	41	35
Light processes	-	21	5
Group agreements	1/9[2]	1/59[3]	1/50[3]
(agreements/companies)			
Total number of companies	30	121	90
Total number of industrial companies	30	62	40

1 Estimated
2 Condensed milk factories
3 Greenhouses

Energy consumption by the 1996- and 1997- companies corresponds to 37% (61 PJ) of the total energy use in industry (see Table 4). It is expected that the energy use of these 200 companies will correspond to 50% of the total energy use in industry. If this is realized half of the industrial energy consumption will be covered by high taxes (space heating and light processes without agreement) while the other half is covered by low taxes and agreements.

The companies with an agreement are expected to decrease their energy consumption by 1.7%, due to the projects described in the three-year agreements. Further savings are expected since several companies have agreed to investigate a number of specific energy-saving opportunities during the three-year period. Also, the agreed activities in relation to energy management are expected to result in further energy savings.

Table 4. Energy consumption and calculated reductions

Agreement	Consumption in PJ	Reduction in %	Reduction in PJ
1996-agreement	48	1.4	0.71
1997-agreement[1]	13	2.7	0.35
In total[1]	61	1.7	1.06

1 The agreements with greenhouses are not included.
Source: Ahé et al., 1998.

4 Evaluation of Agreements – Case studies

In 1997 AKF carried out a study of the first agreements entered in 1996 (Krarup et al., 1997). This study comprised seven case studies on the basis of interviews with consultants, civil servants, and representatives from five of the companies with individual agreements and two companies with a group agreement (in total, 28 people have been interviewed).

In 1998 a second evaluation comprising case studies of four individual agreements entered in 1997 and an up-dating of the 1996-group agreement study has been carried out. This second study (Ingerslev et al., 1998) puts emphasis on the implementation of energy management in relation to the agreements. Below we shall summarize the main findings of the two studies.

4.1 Energy Audits

The aim of an agreement is to ensure that the companies act energy efficiently. Therefore, the definition of "an energy-efficient company" and the way in which this is interpreted in the agreements is a key issue. In principle the definition of an energy-efficient company is objective, but in practice it is very much influenced by the problem of asymmetric information; one negotiating party, industry, has detailed information on the opportunities and limitations in relation to energy savings in their specific production. The other party, the DEA, has little detailed information and must rely on other sources, such as the energy audit.

In reality the energy audit report determines whether the company is considered energy efficient or whether it has to carry out major investments in energy-saving measures in order to enter an agreement. Therefore the energy audit plays a central role as a base for negotiations between companies and the DEA and it is essential that the audit is of high quality.

Most of the companies in both studies received their first energy audit in relation to the introduction of the CO_2 tax in 1993. This audit was concentrated on service equipment – such as lighting, compressed air and cooling (Ravn et al., 1994). The second energy audit focussed on the core areas of production—the energy intensive processes. However, many basic issues on energy use and in relation to energy management were dealt with in the first audit, and therefore the first energy audit have been useful in relation to the reception of the new audit.

In general, the companies are content with the shift in focus of the energy audit, now concentrating on the energy intensive processes. However, it is also clear that it is difficult for the consultants on their own to come up with energy-saving projects on these core areas of the production as they often lack specific knowledge about the processes. Both studies show that the companies think that the energy audits sum up existing knowledge rather than they help identify new potentials for energy savings. In spite of the modest results derived from the audits most companies think that the audits have an effect because it put energy savings on the company agenda, map the energy consumption and specify the profitability of investments.

4.2 Verification

From 1997 all energy audits are verified by an independent and certified organization in order to ensure an acceptable quality standard. The cost of the verification is paid by the companies. In general the companies are discontent with this demand as the verification as such is regarded to be of no use for the individual company. However, the obligatory verification appears to be of relevance: In 1997, the DEA has placed eight consultants on an observation list due to unsatisfying audits. These consultants may lose their right to perform energy audits if future energy audits lack high quality.

4.3 The Negotiation Process

The study of the 1996-agreements showed that very little negotiation took place in relation to the entering of most agreements. When the energy audits were accepted by the DEA, the agreement was straightforward: The companies should carry out all profitable projects. Although the definition of profitability with pay-back periods of four to six years (depending on the type of agreement) deviates considerably from pay-back periods that industry normally accepts, the companies have not protested against this criterion. When negotiation took place, it was in relation to aspects like the time table for realizing the projects and the need for further investigations.

Few meetings (often one or two) were held and time was used on administrative questions, like the correct use of energy prices and interpretations of the guidelines. Also, questions concerning the adequacy of the audits have been raised, e.g.: *have all relevant parts of the energy use been analysed in the energy audit?* The main impression is a process of following the rules—not of give-and-take negotiations.

4.4 Energy Management

The study of the 1996-agreements finds that the activities in relation to energy management are performed at an unsatisfactorily low level when compared to the intention in the guidelines. Large energy flows are only measured at monthly intervals, and few key figures are calculated[1]. From 1997, the guidelines concerning energy management have been tightened up.

The study of the 1997-agreements examines the energy management part of the agreements more in detail. In spite of the tightening up of the guidelines the implementation of the energy management systems only appears to progress slowly. The companies studied have entered their agreements approximately 9 months before the interviews. Most companies primarily concentrate on improving their *energy accounting* systems, developing more detailed key figures etc. Procedures for energy-efficient investments are still largely informal and questions of targeting, motivating and educating staff remain yet to be addressed in some companies.

The technical elements of the concept thus seem to be easier for the companies to implement than the more managerial elements, which may have to do with insufficient management attention. However, for companies with quality management, and especially environmental management systems, the implementation of energy management appears to be more successful.

The difficulties of implementation do not make the companies give up energy management. The four companies in the case studies with a 1997-agreement and the two companies with a group agreement intend to continue the work with energy management after the expiration of their agreements.

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[1] The same result was found in an evaluation of the 1993-95 agreements, (Kurå et al., 1995).

5　Evaluation of Agreements – Survey

A survey has been used to describe and analyse the energy activities in companies with and without an agreement. The purpose has been to test whether the agreements have an impact on the energy activities, when corrections are made for other relevant variables that differ between companies with and without an agreement. As an example average energy intensity is higher in agreement companies than in companies without an agreement. Without correction for energy intensity a comparison could give misleading results. The four main elements in the survey are shown in Figure 1. The design was inspired by Megdal et al. (1997) and Maxwell et al. (1998).
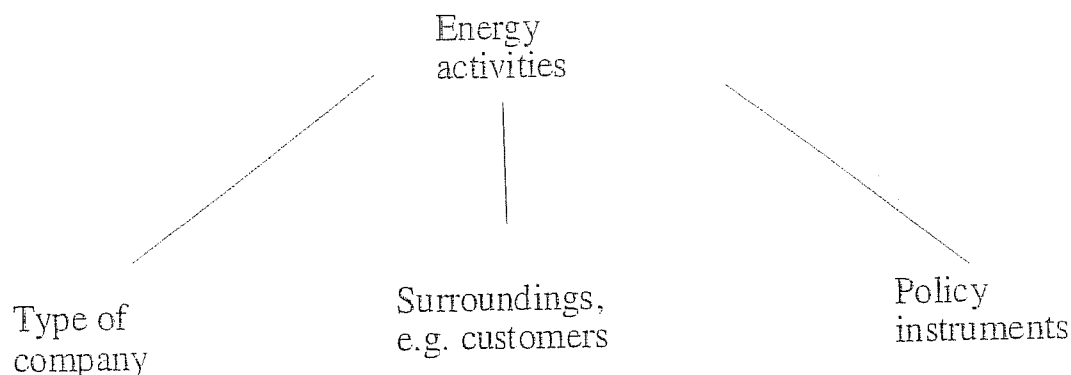
Figure 1. Main elements in the survey

The population for the survey consists of three groups of Danish industrial companies:

- Companies with a new agreement (entered between 1996 and the first month of 1998)
- Companies with an old "agreement"[2].
- All other companies with between 250 and 500 employees

In total 224 companies were selected this way. Only one production site per company was selected. Due to time pressure 40 companies were never contacted. Among the rest (184) 150 companies were interviewed, corresponding to a response rate of 81%. See Table 5.

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[2] From 1993 and 1995. In this period the system where the energy intensive companies were excepted from the CO_2 tax were not officially called an agreement. In reality, all the elements of today's agreements can be found in this system, although in a less strict version.

Table 5. The companies that have been interviewed

Subgroup	Number of companies
Companies with a new agreement (1996-98)[1]	91
Companies with an old agreement (1993-95)	31
Other companies	28
Total	150

1.   Out of the 91 companies with a new agreement 44 also entered an agreement in the first period (1993-95).

Many of the new agreements are entered less than a year ago. Therefore, it was not realistic already now to measure the impact of the agreements on the energy consumption (An ongoing AKF project attempts to measure the change in energy consumption, but the latest complete data are from 1995 (see section 6). The Danish Energy Agency asked for an early evaluation and to this purpose the survey was constructed. (The complete study is described in Buhl et al. 1998 and Togeby and Hansen, 1998). The idea was to give a description of the energy related activities (energy management, the use of key numbers, and realized energy-saving projects) and then study the impact of the agreements on these activities.

The procedure in the study is as follows:

- To construct an indicator of energy management activity based on nine questions
- To explain the variance in this indicator by use of a regression analysis.

5.1   Indicator of Energy Activities

A factor analysis[3] has been used to compress the information from nine questions related to energy activities into a single variable. The nine variables are shown in Table 6. The new variable is used as an indicator of the energy activities in the individual company. It is a linear combination of the nine original variables and range from 0 to 5. A value of 0 corresponds to the lowest level of activities in the sample, while 5 is equal to the highest level of activities.

The new variable is called the *energy management activity index*. The activity index includes 32% of the original information in the nine questions. The signs of the loadings (defining the relation between the nine questions and the activity index) show that an "energy friendly" answer always contributes to a higher activity index. The information in the nine questions not captured in the activity index can, e.g. describe what the companies are emphasising: technical or management skills.

The constructed energy management activity index measures important aspects about how companies work with energy efficiency, but one should be aware that inclusion of other information than the nine questions could influence the analysis.

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[3] See Kim and Mueller (1978) for an introduction to factor analysis.

Table 6. The nine questions forming the basis for the activity index

Do your company use key figures, where energy consumption is related to production?
Has staff been trained in energy management and energy efficiency within the last year?
Is training of staff in energy management and energy efficiency planned for next year?
The number of key figures evaluated each month (or more often)? *
The share of staff that has been educated in energy efficiency or energy management *
Number of energy efficiency projects that has been realized within the last year *
To which degree is the management engaged in energy efficiency? (a scale from 1 to 5)
To which degree is staff actively involved in the work with energy efficiency? (a scale from 1 to 5)
How would you describe the energy savings realized due to the energy management system? (insignificant, neither/nor, considerable)

*   These answers have been transformed before entered in the factor analysis.

The main question is whether companies with an agreement have a higher or lower activity index than other companies when controlled for other differences, like energy intensity. This is analysed with a multiple regression analysis. Parameters describing company type (13 parameters, e.g. energy intensity, industrial sub-sector, and type of product), company environment (9 parameters, e.g. whether the customers are engaged in environmental issues), and exposure to policy instruments (11 parameters, e.g. which energy and environmental regulation the company has been exposed to, the use of subsidies) have been tested. After a number of tests the result described in Table 7 has been reached. Only parameters with a significance of better than 5% are included.

Companies from certain sectors and of a certain production volume must have an environmental approval before year 2000. This is defined in the environmental regulation (Moe, 1995). Most of these companies have already received the approval. These companies are in general complicated—both technically and in relation to the potential environmental problems.

Table 7. Parameters that can explain the variance in the constructed activity index

Variable	Coefficient
Energy intensity (logarithm to energy costs per employee)	0.56
Existence of an energy department	0.53
Sector 1: Agriculture Sector 20: Wood and Paper industry Other sectors	-0.53 -0.38 0
Number of received investment subsidies	0.073
Agreement No agreement, but with environmental approval No agreement, no environmental approval	0.70 0.70 0
Adjusted R^2 N	37% 114

Only 114 companies are included in the regression analysis since 36 companies have not answered all questions, e.g. for 25 companies the energy intensity could not be calculated. With the included parameters 37% of the variance in the activity index could be explained.

The impact of agreements and environmental approval, is illustrated in Table 8. Two levels of the activity index can be found after controlling for energy intensity, the existence of an energy department, sector, and the number of subsidies.

Table 8. Influence of an agreement

Gray area: High activity index (+0.70)		Agreement	
		Yes	No
Environmental approval?	Yes		
	No		

Companies with an agreement only pay reduced CO_2 taxes. Companies with environmental approval have the same level of the activity index with or without an agreement. Therefore, the result can be interpreted as: *An agreement leads to the same level of energy activities as paying the full tax.* For companies without the environmental approval the situation is different: *An agreement leads to a higher level of energy activities than paying the full tax.* Since the agreements have been entered less than 2 years ago, the result seems quite positive.

5.2   Other Results

The agreement companies have been asked about the size of the realized energy savings and to which degree these savings would have been realized without the agreement (see Table 9). A 1.4% reduction due to the agreements is expected within the three years period[4]. In addition to

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[4] The reported savings (2.2%) is higher than found in table 4 (1.7%). In table 9 the savings are weighted by energy costs, while the savings in table 4 are weighted by energy consumption in physical units. If a company with expensive fuels saves more than the average company, weighting with costs would lead to higher results.

this further savings can be expected in relation to the improved energy management and the investigations.

Table 9. Energy savings as reported in the survey

Energy saving due to the agreed projects	2.2%
Would have been realized anyway	34%
Net impact of agreements	1.4%

Note: The answers have been weighted with the energy expenses in each company. Large companies report smaller savings. 67 of the 91 interviewed companies have answered.

Energy management is included in the agreements. The energy manager has been asked whether the agreement had influenced his job and his possibilities to give priority to the energy area. Table 10 shows a clear positive judgement. 74% of the energy managers have noted a positive impact.

Table 10. The agreements' influence on the role of the Energy Manager

Negative impact	2%
No impact	24%
Some positive impact	54%
A marked positive impact	20%

6 Evaluation of Prices and Taxes

AKF and Statistics Denmark have constructed a unique database by combining existing data concerning energy consumption and economic activity in industrial companies. The purpose is to study the influence of prices and taxes. Especially it will be investigated how different groups of companies react to changing prices.

The database covers the years 1983, 1985, 1988, 1990, 1993, and 1995, which are the years where Statistics Denmark has completed a survey concerning energy consumption in all industrial companies with more than 20 employees. To each observation of energy consumption information is added from the accounting statistics, e.g. value added.

In the database each company can be identified over time (a so-called panel database) and the analysis is carried out on company level. This kind of analysis has at least three analytical advantages compared to the commonly used analysis of aggregated data:

I. Larger variation in the parameters and many observations make it easier to find relevant and significant relations.

II. It is possible to test the influence of parameters that are lost when aggregating data, e.g. company size, energy intensity, and the existence of an energy manager.

III. An individual constant can be devoted to capture unobserved information, influencing the level of energy efficiency. This is important since companies are so different, e.g. concerning products, production equipment (type, vintage, and efficiency) and managing style.

Here we will present the first results of analysing the *electricity consumption* by use of the database. For a full description of the database and the estimated models, see Bjørner et al.

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(1998).

The equation used for the analysis is:

$$\text{Log}(E_{it}) = \alpha_i + \beta_c \text{ Log } (P_{it}) + \delta_c \text{ Log } (V_{it}) + \tau_t$$

E is the electricity consumption. V is the value added in fixed prices (a sector specific deflator has been used). P is the electricity price. The four Greek letters are the estimated constants. α_i is a company specific constant that captures time-invariant unobserved heterogeneity as a fixed effect, β is the price elasticity, δ is the production elasticity. τ is a constant per year—this models the technological development and other temporal issues. Subscript it denotes company i at time t. Subscript c is a vector describing company characteristics: Company size (four levels), electricity intensity (two variables: electricity compared to value added and electricity compared to total energy consumption—four levels each), industrial sub-sector (21 sectors) and ownership (4 types). In total 37 dummy parameters are used to describe the company characteristics. No interaction terms between company characteristics are included[5] As we shall see, the price elasticity does not depend on company size, so the number of elasticities reduces to 33.

Other parameters have been tested but have not shown to been significant. This includes a parameter for those companies with an agreement with the Danish Energy Agency in 1993-95 (only 50 companies in the database) and the existence on an energy manager. Also, an individual trend for each sector has been tested. A level of significance of 1% has been used in the analysis.

Two thousand seven hundred seven companies are represented in three or more years in the database, giving 12,733 observations for the analysis. The model structure gives a large number of parameters. In total 2,843 parameters are estimated in the model we present here. 2,777 of these parameters are the individual constants ($_i$). For the case of simplicity only a few of these will be presented (see Table 11 and Figure 2).

The Table 11 and Figure 2 shall be read as follows: to get the elasticity for a subgroup, the average value must be corrected for the sub-sector, company size, electricity intensity, electricity share and ownership. Table 11 shows the variation of the size of the corrections, while figure 2 shows the corrections for electricity intensity and share.

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[5] The population is divided into 21*4*4*4*4=5,376 groups, but only 21+4+4+4+4=37 parameters are estimated. In this way the variables are considered to be independent, e.g. electricity intensity has the same influence in all sectors.

Table 11. Elasticities for production and price

	Production		Electricity price	
Average level	0.69		-0.41	
Influence of other variables:	Min	Max	Min	Max
Sector [1]	-0.18	+0.14	-0.12	+0.15
Company size	-0.003	+0.003	-	-
Electricity intensity[2]	-0.09	+0.11	-0.09	+0.10
Share of electricity share[2]	-0.07	+0.07	-0.11	+0.12
Ownership	-0.004	+0.009	-0.07	+0.16

1. Four sectors with less than 100 observations are excluded.
2. The individual values for the price elasticity are shown in Figure 6.1.

The average price elasticity is -0.41, indicating a reduction in electricity consumption of 4.1% if the electricity price increases with 10%. In the same manor the average production elasticity indicates that the electricity consumption will increase with 6,9% if production increases with 10%[6].

Company size has shown not to influence the price elasticity, but four other company characteristics are important: Sector, electricity intensity, share of electricity, and ownership. High electricity intensity as well as high share of electricity gives a (numerical) higher price elasticity. *Where electricity costs are important, the reaction to price changes are the strongest.*

Electricity intensity
Electricity share
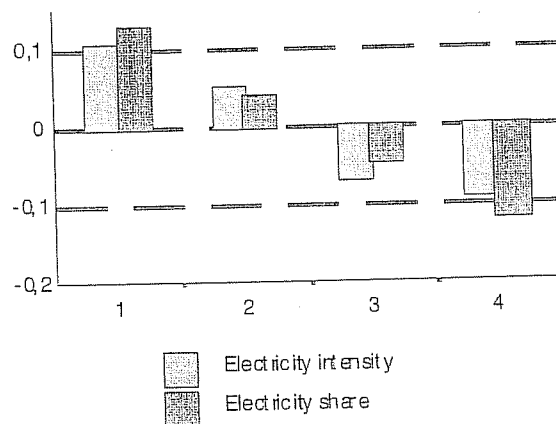
Figure 2. Influence on price elasticity. Values to be added to the average, -0.41. The codes for electricity intensity and share: 1: Low and 4: High.

The large number of parameters (production elasticities and the individual constants) insures

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[6] The average elasticities are average over all sub groups (not weighted by energy consumption). The elasticities describe how existing companies are reacting. The raise of new companies and the elimination of other companies are not considered here.

that the found relation concerning price elasticity is not the result of some hidden relation. The total model is strongly significant ($p < 0.1\%$). None of the presented parameters can be excluded from the model ($p < 0.2\%$).

This is our preliminary result. The elasticities can be influenced by an altered model structure, but we expect that the general result—price matters—will survive.

Future model development will include all energy sources, capital and labour. In a more general model cross elasticities can be estimated. Information about energy consumption in 1996 is already included in the database. Soon information about economic activity in 96 is available. Then 1996—the first year of the second generation CO_2 taxes—will be included in the models.

7 Conclusion

CO_2-taxes for industry and agreements were introduced in 1993. Regulation of energy consumption in industry was a new area for the authorities and several evaluations have been performed to help adjust the schemes.

For the companies with agreements (and lower taxes) several studies suggest improvements in the order of 1-2% of total energy consumption per agreement (three years).

An analysis of the impact of electricity prices suggests an average price elasticity of -0.4. For that half of the industrial energy consumption without agreements, and who typically (in year 2000) will pay an average of 20% tax on energy, this would lead to an 8% reduction in energy consumption (if the average electricity price elasticity is applied to all energy consumption).

7.1 Discussion

The described savings are regarded as higher than what can be realized by more voluntary policy instruments, like information, partnership and subsidies.

The slow introduction of the taxes is regarded as very helpful for the companies to have time to adjust to the new price signals. If improvements are continued to be introduced in the regulation, the goal of a 4.6% reduction in total CO_2 emission in year 2005 seems to be within reach. Improvements could include increasing the lowest levels of the taxed for the period after year 2000.

8 Acknowledgements

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II. Voluntary Agreements

Evaluation of Energy-Related Voluntary Agreements

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Summary

Voluntary agreements have become a widespread approach to improving energy efficiency and reducing greenhouse gas emissions in the industrial sector. Their popularity stems from their lower cost, potentially faster results, superior adaptability to the complexity of the industrial situation and greater political consensus compared with other policies. However, the credibility of voluntary agreements is a major issue. The voluntary nature of these instruments gives rise to a certain amount of scepticism about whether they actually compel industry to improve beyond "business as usual." Rigorous and routine evaluation is vital to keeping participants diligent in the pursuit of their commitments and demonstrating to the public the extent that voluntary agreements accomplish their goals.

This paper. drawing heavily from the IEA report, *Voluntary Actions for Energy-Related CO_2 Abatement*, reviews energy-related voluntary agreements with industry; outlines common issues associated with the measurement and evaluation of energy efficiency policies; and describes some initial results from evaluations of voluntary agreements.

1   Introduction

Governments throughout the world are studying, developing and implementing numerous policies to slow the growth in energy use and greenhouse gas (GHG) emissions. While the primary goal of these measures is to meet international commitments on climate change, most also seek to improve economic efficiency and competitiveness, energy security, consumer well-being, and, in some cases, reduce government spending. In reconciling these aims, governments are increasingly reluctant to impose heavy fiscal or regulatory requirements on firms that must compete in global markets. They are accordingly turning to innovative ways of working with industry to achieve shared objectives through cooperative approaches. Voluntary agreements (VAs) have become especially popular in this regard. They are being used to persuade industrial firms, commercial enterprises, electric utilities and municipalities to voluntarily set and meet energy efficiency and GHG emission reduction goals, and raise the profile of environmental issues in their decision-making practices. Participants are left to achieve the goals in the ways that best suit their economic, social and political circumstances. For their efforts, the participants are given favourable public recognition by government, and

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[1] The views expressed in this paper are those of the author, and do not necessarily reflect the official position of the International Energy Agency or the governments of IEA Member countries.

may also receive technical assistance, subsidies, regulatory exemptions, or relief from further taxation and regulation.

The IEA conducted a survey of voluntary actions for energy-related CO_2 abatement in 1995/96, identifying some 350 different voluntary programmes in 22 countries and the European Union.[2] More than 200 current or planned voluntary agreements, actions and initiatives were found in the industrial sector. The actions range from (1) informal programmes, self-commitments and declarations in which parties set their own targets and often do their own monitoring and reporting to (2) more formal approaches involving a contract between government and industry or negotiated targets with commitments and time schedules on the part of all participating parties. The main reasons that were cited for governments' adopting such actions were:

- to promote increased involvement of firms and the business sector as a whole in energy efficiency improvements and GHG emission reduction activities;

- to increase industries' and consumers' motivation and responsibilities to save energy and costs, and achieve climate change mitigation and other environmental objectives; and
- to permit the definition of policy instruments better adapted to the prevailing economic and competitive context.

2   A Definition

Many industrial companies—individually or through their branch organisations—have voluntarily committed themselves to undertake actions to support social goals via a wide variety of instruments, including industrial covenants, negotiated agreements, self-regulation, codes of conduct, eco-contracts, and voluntary technical standards.[3] Voluntary agreements, a subset of these approaches, are *agreements between government and industry to facilitate voluntary actions with desirable social outcomes, which are encouraged by the government, to be undertaken by the participants, based on the participants' self-interest.*[4] By this definition, VAs does *not* include actions undertaken without government initiative (or through the initiative of non-governmental bodies) or that are undertaken at government mandate. In the context of energy and environmental policy, the desirable social outcome can range from corporate and public awareness building in early stages to actual energy savings and/or GHG emissions reductions later. The participants' self-interest will vary by industry and by type of VA, but may include profit, public recognition for environmental achievements or the desire to be a good environmental steward. Participants may also receive technical support, financial incentives or exemptions from restrictive command-and-control requirements. Their actions may also help forestall less desirable regulations or taxes in the future. VAs and regulatory strategies need not be mutually excluding, however. They may be, and indeed often are, complementary strategies. Even with regulatory strategies in place, VAs can help persuade and enable participants to go beyond regulatory requirements and/or identify opportunities to

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[2] IEA, *Voluntary Actions for Energy-Related CO_2 Abatement*, OECD, (Paris) 1997.
[3] Voluntary technical standards on environmental management systems, such as the International Organization for Standardization (ISO) 14000 series and the European Commission's Eco-Management and Audit Scheme (EMAS), specify how businesses can assess, implement and improve their environmental performance.
[4] Storey, M., *Demand Side Efficiency: Voluntary Agreements with Industry, Policies and Measures for Common Action*, Working Paper 8, (OECD, Paris) 1996.

reduce regulatory cost burdens.

Many characteristics differentiate VAs, among them: the manner in which targets or goals are set, the nature of participant commitment, the degree of regulatory or fiscal threat, and the mix of VA participation incentives.[5] Based on these key characteristics there are four major types of VAs.

Target-Based VAs (sometimes called negotiated agreements) having negotiated targets that are legally binding, pre-empt future regulatory requirements or tied to a strong regulatory threat.

Performance-Based VAs having negotiated performance goals[6] that are neither legally binding nor explicitly designed to pre-empt future regulatory requirements.

Cooperative R&D VAs spurring new technology developments that advance best commercially available equipment/processes and best management practices.

Monitoring and Reporting VAs offering monitoring and reporting elements, similar to those in most other VAs, as agreements themselves.

In practice, individual VAs often have the features of more than one of these categories.

2.1   Some Examples

The sectors targeted for voluntary agreements are primarily large companies and energy intensive sectors such as steel, aluminum, refineries, chemicals, cement, glass, pulp and paper, and fertiliser production. Among the industrial voluntary agreements with specific targets and deadlines found in the IEA survey were:

e   The Canadian Industry Program for Energy Conservation (CIPEC) operating on the sectoral level to help industry identify energy efficiency opportunities, to forecast and set cost-effective targets, and to implement actions plans to meet them. The industry sectors participating in CIPEC made a commitment in 1994 to use energy efficiency to voluntarily stabilise their CO_2 emissions at 1990 levels by 2000 provided that industrial growth does not exceed 2% per year. Within this broad commitment, the different industrial sectors can specify more specific targets.

o   The Dutch Government's Long-Term Agreements (LTAs) with 31 industrial sectors (as of 1 January 1997), covering more than 90% of industrial primary energy consumption, to improve energy efficiency by about 20% for the period 1989 to 2000. The basis for the targets is different for each industrial sector. There is no single cut-off payback period, but only economically viable measures are included. The agreements are legal contracts between the Government and representatives from the industry and service sectors that outline broad areas of action to improve energy efficiency, including contributions to be

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[5] VAs can be classified by other characteristics as well. For example, a U.S. Department of Energy draft paper on *A Typology of Voluntary Agreements Used in Energy and Environmental Policy* characterises VAs according to 21 parameters.

[6] Performance *goals* can have some similar elements as *targets*, namely meeting some emissions reduction or energy efficiency objectives, but typically include a broader set of actions. For example, the adoption of certain targeted technologies that are economically viable or the implementation of an upgrade/evaluation plan.

made from measures such as energy management, combined heat and power, improvement in power generation, heat integration, and modernisation of processes. For its part, the Government assures some consistency and protection from new regulations. It also provides financial and technical support in exchange for voluntary participation.

• The Finnish Government's agreement with industry and the energy sector to achieve energy savings for heat and electricity production of 5-15% by 1996 and 2005, based on 1990 levels. This initiative has been replaced by a more company-centred one in which individual companies accede to a framework agreement between the Government and the Confederation of Finnish Industry and Employers. Companies that accede commit themselves to report on their energy use, perform energy audits and analyses, appoint a person responsible for energy conservation within the organisation, set energy efficiency targets and draw up plans to achieve the targets. The Government agrees to contribute to companies' energy audits and analyses and conservation investments within budgetary limits. The Government and the Confederation also agree to cooperate in monitoring the implementation of the agreement, in developing contractual activities, and in developing training programmes for companies' personnel.[7]

• The 1996 "Updated and Extended Declaration by German Industry and Trade on Global Warming Prevention", in which 19 industrial and electrical utility associations, representing more than 71% of industrial energy consumption and more than 99% of public power generation, proposed to reduce their specific emissions of CO_2 or their specified energy consumption by up to 20% in the period from 1990 to 2005 based on voluntary measures. In return, the industry expressed its hope that the Federal Government would favour private-sector initiatives over regulatory and fiscal measures, in particular regarding a proposed regulation on heat use, or plans for a CO_2 tax.

3 Reasons for Popularity

Although several countries have conducted industrial commitment and recognition programmes since the 1970s, VAs and other voluntary actions are becoming increasingly widespread. The recent popularity is due to growing concern that climate change objectives will not be achieved without innovative, consensus-building approaches that have the active support of programme participants. The IEA survey found that voluntary programmes enjoy strong support by industry and the business community, while there can still be reservation and scepticism expressed by some regulatory authorities, environmental non-governmental organisations and the public. The potential drawbacks and expected benefits for using voluntary actions are outlined in Table 1.

[7] Lahti-Nuuttila, T., "Long Term Agreement System – Finnish Model for a Voluntary Measure of Energy Efficiency in Industry," *Proceedings of the European Conference on Industrial Energy Efficiency 'Success Stories'*, Vienna, Austria, 8-10 July 1998.

Table 1. Benefits and Drawbacks of Voluntary Approaches

Benefits	Drawbacks
Company can choose most effective means to reach target; "tailored" to circumstances	No guarantee parties will obey or will not abuse agreements
Adaptability, flexibility and greater stability in long-term requirements	No incentive to go further than the agreed objectives, which may appear
Takes into account industry's concerns; promotes understanding and trust in industry	Technological innovation may not be encouraged unless stated or included in the agreement
Based on consensus, promotes continuous dialogue between industry and government	Number of participants could be restricted due to transaction costs
Devolves responsibility to local company level and integration of environmental improvements into business planning cycle	"Free-riding" through non-compliance or non-participation
Encourages innovation and improves efficiency of compliance	Transparency, accountability and monitoring are essential
Potentially more efficient and quicker to develop and implement	Still can be time-consuming to negotiate and bureaucratic to implement
Provides "green image" to participating firms	May be difficult for firms to pass costs to others through higher prices for goods and services
Promotes information exchange on best practices and potential cost savings	May not be sufficiently credible with the public

IEA, Voluntary Actions for Energy-Related CO_2 Abatement, OECD, (Paris) 1997.

The motivation for industry to engage in voluntary actions is often the "voluntary" commitment by government not to implement other policy instruments, provided that industry fulfils its part of the agreement. It is usually understood that failure by industry to carry out its voluntary initiatives or commitments implies that governments may resort to other policy instruments and measures, such as taxes and regulation. The attractiveness of VAs for industry is their flexibility—which translates into lower costs and fewer competitive advantage problems—compared with alternative policy measures such as taxes and further regulation. VAs can also contribute to the "green" images many companies wish to portray.

The advantages for government are the prospects of gaining CO_2 reductions relatively quickly with low costs. The survey found that many officials believe that voluntary programmes can achieve energy and environmental objectives faster than regulations. Regulation, one alternative policy measure, is difficult to implement in industry because of the great variety of energy use in industrial facilities. Moreover, regulations can require years for development and approval. In contrast, VAs are more adaptable to the heterogeneous and dynamic nature of industrial energy use and can be developed relatively quickly. The greater adaptability of VAs means they can seek energy efficiency gains and CO_2 emissions reductions beyond those possible through regulation. For example, they can encompass energy management, technology innovation and structural measures that are not always amenable to regulation.

Another important aspect of VAs is the cooperative manner in which they are developed. The IEA survey found widespread belief that a less confrontational, more interactive approach to achieving energy and environmental policy will bring greater results. Since VAs are entered into voluntarily and developed in collaboration with companies and trade associations rather than by governing bodies alone, such agreements are seen to have a better chance of garnering support from industry than direct regulation of energy efficiency or taxation of energy or CO_2. Moreover, the increased trust and strengthened sense of partnership and mutual responsibility between government and business can be the base for the development of more ambitious goals than those required by regulation.

4 Policy Measurement and Evaluation

Measurement and evaluation of policy and programme performance helps improve the operation, management, oversight and planning of these instruments by promoting transparency and realism of goals, enhancing financial and managerial accountability, highlighting progress towards goals, and identifying barriers to success. These issues are becoming increasingly important because of tighter constraints on public budgets, greater demands for political accountability and increased pressures of international commitments. Performance measurement and evaluation enable politicians, policy professionals, programme managers and staff, and taxpayers to ascertain whether programmes are meeting objectives and public money is being well spent. In the case of energy efficiency, these stakeholders need to know whether energy efficiency programmes have resulted in improved energy efficiency, energy savings and/or reduced GHG emissions and whether the programmes might be improved and savings increased.

Performance measurement systems may be used to support many managerial functions (control, monitoring, motivation, evaluation, accountability) and elements in the production and policy cycle (input, activities, outputs, outcomes and environment). The main objective of performance measurement and programme evaluation is to support better decision-making in order to[8]:

- improve the performance of the organisation with respect to economy, efficiency, effectiveness, service quality and financial diligence;[9]
- improve control measures for programme designers, managers and government ministers and accountability mechanisms for external reviewers such as auditors and legislators;
- inform the budgetary process by providing decision takers with information which links programme performance and budgets; and
- motivate staff to improve performance.
- Measurement and evaluation efforts focus on various stages of the policy and programme stream. The various stages can be classified as programme inputs,

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[8] OECD, Public Management (PUMA) Occasional Paper 1994, No. 3, *Performance Management in Government: Performance Measurement and Results-Oriented Management*, (OECD, Paris) 1994.

[9] Economy — obtaining resources at lowest cost possible. Efficiency — the relationship between output and the resources used to produce them. Effectiveness — the extent to which the intended objectives or outcomes are achieved. Service quality —the relation between programme output and programme delivery encompassing timeliness, accessibility, accuracy and continuity of services, and the level of comfort and courtesy given to users. Financial diligence — revenue earning, user charging and grant dispensing organisations have objectives related timeliness and client burden.

programme outputs, programme outcomes and market effects.[10] In the context of voluntary agreements,

- programme inputs include the funds and personnel time required to develop, administer and evaluate agreements, and the cost of incentives offered to programme participants,
- programme outputs include the number of agreements and participants, and the ambitiousness of the commitments to implement energy savings and/or GHG emissions reduction measures,
- programme outcomes include the number and quality of monitoring reports submitted by participants, and the extent to which participants implement investments and other measures, and
- market effects include the actual energy efficiency improvements and GHG emissions reductions beyond business as usual achieved by participants.

Determining the true market effects of energy efficiency policies is not easy.[11] It is difficult to measure energy efficiency and GHG emissions changes for particular industrial plants and branches, while taking into account business cycles, economic trends and industry's structural shifts. It is even more complicated to distinguish the changes in energy efficiency and GHG emissions caused by policies from those caused by other factors. And these tasks are still harder and more costly when policies and programmes are not designed from their inception to be evaluated. Several aspects of designing programmes for evaluation deserve mention:

Clear Programme Goals. Programmes should have explicit, and to the extent possible, measurable, goals against which performance can be measured. This is particularly difficult with VAs, because they attempt to address at the same time a variety of goals (corporate awareness building, fuller participation of business in developing policy initiatives, energy savings and GHG emissions reductions).

Data Collection Coordination. The data needed for programme evaluation is often similar to those required for programme implementation. From the outset of the programme, the data activities for both the implementation and evaluation phases should be coordinated in order to reduce the overall data collection and analysis effort.

Business as Usual (BAU) Baseline. Programmes should be established against the background of a credible BAU baseline of energy use and GHG emissions with relevant corrections for business cycles, economic trends and industrial structural shifts.

Free Rider Effects. Attention should be to given to dealing with participants that enjoy the programme's benefits (e.g. public relations, tax/regulation relief) without making and meeting commitments beyond their individual BAU. In the case of VAs with industrial firms and associations, this requires a great deal of information and expertise at the Government's disposal.

Integration of Planning and Evaluation. Planning and evaluation are two closely related

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[10] Natural Resources Canada, *Influencing Energy Use in Canada, Progress Indicators on Initiatives Delivered by Natural Resources Canada*, August 1996.

[11] Full discussion of the measurement and evaluation of energy efficiency policies and programmes is beyond the scope of this paper. More thorough exposition can be found in IEA, *Evaluation, Verification and Performance Measurement of Energy Efficiency Programmes*, contractor report prepared by D. M. Violette, (unpublished) 1996.

activities, which must inform each other. Planning involves setting targets that are realistic for a given level of policy ambition. Evaluation involves judging actual programme performance against those targets. The evaluation results must then be fed back into the planning system in the form of improved bases for planning future programmes and, perhaps, revising targets for the current programme.

Consistent and Transparent Reporting. With VAs, it is necessary to rely largely on participants' reports to monitor progress of the programme. Clear guidelines should be given to participants on how to write reports that are understandable as well as easily comparable to the reports from other participants. Regular publications describing measures taken and results achieved, not only lends credibility to the programme, but also helps raise corporate awareness about energy efficiency opportunities and best practices, and contributes to building a culture of continuous energy efficiency improvement.

Data Confidentiality. Measures need to be taken ensure confidentiality of certain data provided in the participants' reports. However, some information needs to be made available for public scrutiny. Industry and branch associations can be important intermediaries in centralising, collecting and coordinating information provided by companies, and establishing common measurements, units and baselines against which progress can be measured.

Correlation with End-Use Indicators. In-depth evaluations, though expensive, can ultimately save governments money by increasing programme performance and efficiency. Still, techniques for correlating evaluation results with less costly energy use indicators should be developed in order to achieve the same programme performance, efficiency and credibility benefits with fewer in-depth evaluations.

5   Results From Some Evaluations of Voluntary Agreements

The widespread use of voluntary agreements has been a relatively recent development, and only a few evaluations—beyond the compilation of monitoring reports—of these instruments have taken place. These will be described only briefly here, as several are the subjects of other papers in this workshop.

5.1   The Netherlands: Long Term Agreements (LTAs)

Researchers at the University of Utrecht conducted an evaluation of the *Dutch LTAs* in 1997.[12] Among their findings are:

- LTAs make a demonstrably significant contribution to generating improvements in energy efficiency, accounting for 25-45% of the energy efficiency improvements in the Dutch industrial sector.

- Participation in LTAs raises companies' level of housekeeping and energy management efforts and awareness of conservation in investment situations.

- The level of "free ridership," companies signing on to LTAs but not making efforts to meet their commitments, is limited.

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[12] Dutch Ministry of Economic Affairs, *Long Term Agreement on Energy Efficiency, Progress 1996*, March 1998.

The evaluators also made recommendations for further improving the quality of LTAs in the future, including a proposal to strengthen the Energy Conservation Plans by requesting more concrete information on the measures to be taken, and to further harmonise the monitoring system. Elsewhere in these workshop proceedings, Nuijen presents further information on LTAs and this evaluation, and Rietbergen, Farla and Blok present the methodology and results of the evaluation's quantitative assessment of the goal achievement, effectiveness and efficiency of LTAs.

5.2   Denmark: CO$_2$ Tax and Agreement Scheme

The Institute for Local Government Studies – Denmark (AKF) has assessed the *Danish CO$_2$ Tax and Agreement* scheme, whereby companies with heavy processes or/and high levels of energy consumption can receive tax reductions if they enter into agreements on energy efficiency with the Danish Energy Agency. Through case studies and a survey, AKF examined the role played by the energy audit reports upon which agreements are negotiated and the impact of the agreements on energy-related activities, such as energy management, energy accounting and realised energy-saving projects. The evaluations concluded that the agreements have a positive impact on energy savings and increased activities in relation to energy management. Elsewhere in these workshop proceedings, Togeby, Bjørner and Johannsen describe the evaluation techniques and the results in fuller detail.

5.3   Germany: Declaration of German Industry for Climate Protection

The Rhine-Westphalia Institute for Economic Research (RWI), an independent research institute, is charged with monitoring the implementation of the *Declaration of German Industry for Climate Protection* and reporting annually on the results.[13] In 1997, RWI's "First Monitoring Report: CO$_2$-Emissions in German Industry 1995-1996" showed:

- Between 1990 and 1996, the reduction in total energy-related CO$_2$ emissions by the industrial sector involved in the VA was 42 million tonnes (a 20.6% reduction from the base year). The chemicals industry reduced its emissions by 15.9 million tonnes (24.2%) and the iron and steel industry by 12 million tonnes (17.1%).

- Reductions can be broken down into two different phases. The 1990-1995 phase, before the VA existed, was characterised by restructuring in the new Länder and large improvements in energy efficiency. In some cases the targets set in the VA for 2000 were already achieved in 1995. After 1995, enterprises cannot make the same reductions and their targets need to be redefined. The base year to measure the progress could be 1995 instead of 1990.

- A large number of actions reducing CO$_2$ emissions have occurred, but cannot be attributed to the VA alone.

- The process is still in an experimental phase and needs to be improved.

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[13] IEA, *Energy Policies of IEA Countries, Germany 1998 Review*, (OECD, Paris) 1998. See also B. Hillebrand, H.G. Buttermann and A. Oberheitmann, *First Monitoring Report: CO2-Emissions in German Industry 1995-1996*, Essen, 1997. (Introduction and Conclusions available at http://www.rwi-essen.de/english/ver-pa50.htm).

6   Conclusions

VAs appear to have many policy advantages and to be capable of yielding major energy efficiency improvements and GHG emissions reductions. However, most VAs are still young and evolving, so it is difficult at this time to fully assess their longer-term effectiveness. Moreover, they face a number of challenges. They need to establish credibility in their capacity to compel industry to go beyond "business as usual". Rigorous and routine evaluation is vital to ensuring the effectiveness of, and political confidence in, any public policy. This is especially important in the case of VAs. Their voluntary nature engenders a certain amount of scepticism about their accomplishments. Monitoring and evaluation is needed to establish the credibility of VAs by demonstrating to the public the extent that they accomplish their goals. In addition, regular monitoring and evaluation helps to keep participants diligent in the pursuit of their commitments, to illustrate avenues for programme improvement and to showcase the accomplishments of participants that set and reach high goals.

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Quantitative Evaluation of Voluntary Agreements on Energy Efficiency

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Summary

This paper evaluates voluntary agreements on energy efficiency, which have been made with several industrial sectors in the Netherlands. The agreements are assessed on the basis of goal achievement, effectiveness and efficiency. A recent study shows an average energy efficiency improvement of 1.7% per year for the period 1989-1995, which is slightly lower than the average 2.0% goal in the voluntary agreements. Three different methods have been developed to assess the effectiveness of the agreements. The first method uses a bottom-up approach to assess the actual effect of the policy. The second method uses a top-down approach to compare the monitored energy efficiency improvement with a simple business-as-usual scenario. The third assessment method assesses the results of the agreements against a base line scenario that is calculated on the basis of a technology database and an implementation model. The results of three assessments indicate that about 25-45% of the energy efficiency improvement in the Dutch industrial sector can be attributed to the implementation of voluntary agreements. The results of the efficiency evaluation suggest that the voluntary agreements are more cost-efficient policy instruments for improving energy efficiency than purely subsidy-based schemes.

1 Introduction

In the National Environmental Policy Plan—plus (VROM, 1990) the Dutch government aimed to stabilise the energy supply in the year 2000 at the level in 1989. The first Memorandum on Energy Conservation (EZ, 1990), issued in 1990, worked out this policy in more detail. In this memorandum as well as in the subsequent policy documents on energy conservation the stimulation of energy efficiency improvement is considered as an effective and efficient policy for stabilising CO_2 emissions. A recent memorandum aims at an energy efficiency improvement of 2% per year also after the year 2000 (EZ, 1998).

The current energy conservation policy is based mainly on self-regulation and voluntary agreements with target groups, supported by financial incentives. As part of the energy conservation policy in the Netherlands voluntary agreements (VAs) on energy conservation have been made with industrial and other sectors since 1992. Industry and the government agreed upon an energy efficiency improvement of 20% in the period 1989-2000. Hence, in a few years the VAs will expire. In the Third White Paper on Energy (EZ, 1995) the government expresses the wish to continue and extend the voluntary agreements with the industrial sector. However, before signing new agreements on energy efficiency the Ministry of Economic

Affairs wants the VAs to be evaluated[1].

This paper aims at the quantitative evaluation of voluntary agreements on energy efficiency in the Netherlands. An interim assessment of the agreements in several Dutch industrial sectors will be presented. For this assessment a rational-instrumental approach is chosen (Bressers 1993). In the rational-instrumental approach policy instruments are evaluated according to the concepts of goal achievement, effectiveness and efficiency. The concept of 'goal achievement' evaluates whether policy objectives are reached or not. The concept of 'effectiveness' questions to what extent the policy instrument contributes to the goal achievement. The concept of 'efficiency' deals with the proportion of costs and benefits of the policy instruments, compared with other instruments. In sections 2, 3 and 4 the methods and results of this evaluation performed according to the above-mentioned concepts will be discussed. The final section of this paper summarises the conclusions of the quantitative evaluation of VAs on energy efficiency.

2 Policy Objectives and Goal Achievement of VAs

The policy evaluation process according to the rational-instrumental approach starts with the assessment of the goal achievement of the VA policy. We analyse whether policy objectives set out in the VA have been reached or not in the specified period. Since results of the VA policy up to 1995 are available, only an interim evaluation of the VAs can be made in this section. We will however discuss whether the goals will be reached by the year 2000.

Industry and the government agreed upon an energy efficiency improvement of 20% in the period 1989-2000. Because of the stated target in the VAs and its subsequent supervision clear definition and monitoring of the energy efficiency improvement are required. For this purpose the Energy Efficiency Index (EEI) and various monitoring methods have been introduced; these will be described in the following sub-section. Sub-section 2.2 shows the results of the study by Glasbergen et al. (1997) on the energy efficiency improvement in various Dutch sectors and compares the results with goals set out in the VAs.

2.1 Energy Efficiency Index and Monitoring Methods

Goals in the VA are expressed in terms of energy efficiency improvement. In the Netherlands the EEI is used as a physical indicator to study the energy efficiency improvement. According to Novem (1995) two general methods can be used to monitor the EEI. This sub-section discusses these two frequently used monitoring systems, i.e. monitoring of specific energy consumption (energy consumption per weight unit of product) and the so-called project-monitoring.

Energy consumption per weight unit of product
This method is based on the monitoring of the specific energy consumption (SEC). The SEC is

a commonly used physical energy efficiency indicator. It is defined as the ratio of energy consumption to a measure of human activity in physical terms. The SEC is expressed as energy consumption per weight unit or product (Phylipsen 1997). Specific energy consumption is defined as follows:

$$SEC_i = \frac{E_i}{m_i}$$

(1)

Where:

SEC_i = specific energy consumption for industrial activity i
E_i = energy consumption required for industrial activity i
m_i = physical production of industrial activity i

In non-profit sectors such as institutional health care, where the ratio of energy consumption to a measure of human activity is difficult to determine, the energy consumption can e.g. be monitored on the basis of gross surface area in square metres or the number of patient days.

After the energy efficiency indicators have been determined at a lower aggregation level, it is often desirable to reduce the number of indicators to more aggregate figures, e.g. at the firm or sectoral level. Therefore the EEI was introduced. The EEI compares the actual energy consumption in a specific year j (E_j) with the reference energy consumption. The reference energy consumption is the amount of energy that would have been used if no energy efficiency improvement had occurred in the evaluated period. The reference energy consumption takes into account structural changes and activity growth within the firm or sector. This quantity is also often referred to as the frozen-efficiency energy consumption.

At a firm level the EEI in year j can be calculated with the following formula:

$$EEI_j = 100 \times \frac{Actual\ energy\ consumption}{Reference\ energy\ consumption} = 100 \times \frac{E_j}{\sum_{i=1}^{n} P_{i,j} \times SEC_{i,1989}}$$

(2)

The reference energy consumption is the product of the specific energy consumption of product i (SEC_i) in the reference year 1989 and the index-linked production of product i, P_j. As the product of index-linked production and specific energy consumption is used, this indicator accounts for structural effects at the firm or sectoral level.

Aggregation of the EEIs at firm level yields a sectoral EEI:

$$EEI_{sector} = 100 \times \frac{\sum Energy\ consumption\ of\ firms}{\sum Reference\ consumption\ of\ firms}$$

(3)

Project-monitoring

Project monitoring is used when the specific energy consumption of a product is difficult to determine, e.g. as a result of the large variety of products. This method only monitors the amount of saved energy. Then the EEI in year x is defined as:

$$EEI_x = 100 \times \frac{E_{1989} - \Delta E_x}{E_{1989}}$$

(4)

E_{1989} is the reference energy consumption in 1989 and ΔE_x are the total savings achieved through projects carried out in the period 1989 till the year x. The disadvantage of this monitoring system is however that the energy efficiency improvement can be overestimated, e.g. in the case where energy-saving measures save less energy than projected, or other measures are taken that (gradually) reduce the energy efficiency.

Other assumptions used in these monitoring methods are:

- Electricity consumption is converted to primary energy requirement and a fixed efficiency rate in the electricity production sector of e.g. 40%;
- The feedstock energy requirement is not included in the calculations of the EEI;
- The EEI does not depend on the introduction of new products or on the removal of products at the firm and branch level.

2.2   Energy Efficiency Improvement and Goal Achievement in The Netherlands in the Period 1989-1995

Most of the VAs on energy efficiency improvement in the Netherlands aim at a conservation target of 20% by the year 2000. At the moment only sub-targets for the year 1995 can be studied. Glasbergen et al. (1997) studied the energy efficiency improvement in various sectors in the Netherlands. In Figure 1 the EEI in 1995 is depicted in black and the target improvement in 1995 of the evaluated sectors is depicted in white. For the sectors that did not formulate a mid-term target, an EEI of 90 in 1995 is suggested, derived from a linear interpolation between 1989 and 2000.

Figure 1: EEI in 1995, EEI in 1989 = 100. Source: Glasbergen et al. (1997):

	Value	Sector
	97,5	Fruit and vegetables
	86,2	Margarine, fats and oils
	90,1	Textiles
	90,1	Industrial laundries
	86,8	Paper and cardboard
	90,7	Chemical
	88,0	Glass
	93,6	Building bricks
	89,2	Iron and steel
	89,0	Greenhouse horticulture*
	96,4	Institutional health care

100   95   90   85   80   75   70   * converted to the base year 1989

Energy Efficiency Index 1995
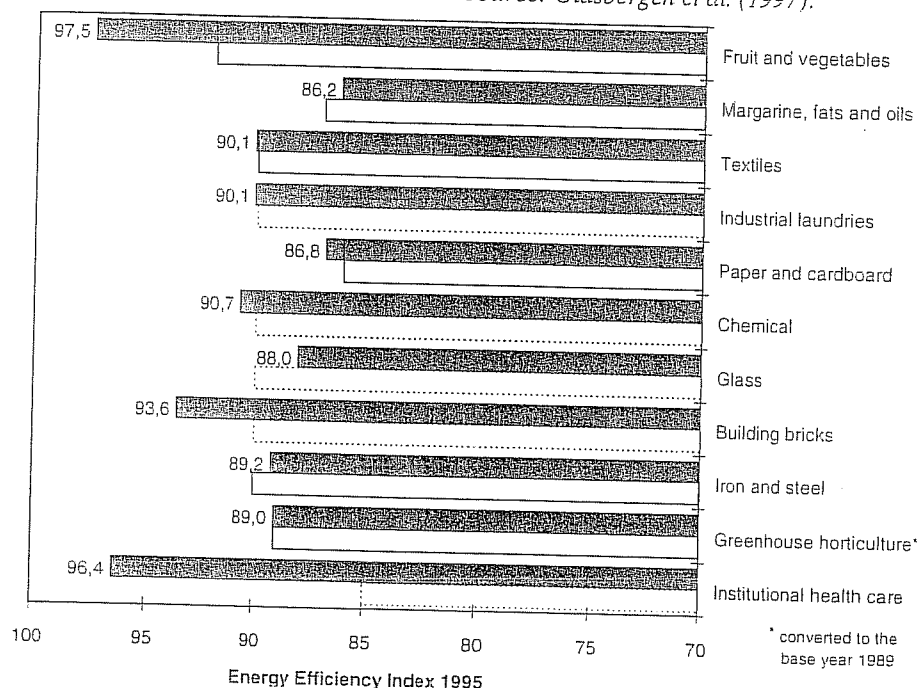
The figure shows three sectors that are far below the target. These are the vegetable and fruit processing industry, the building brick industry and health care. All the other sectors reached the target in 1995 within 1%. If the results up to the year 1995 are extrapolated, the projected energy efficiency improvement in the year 2000, when most of the VAs come to an end, will amount to 18% for all the evaluated sectors in Glasbergen et al. (1997), which is slightly lower than the target of 20%. The 18% efficiency improvement is based on an average annual energy efficiency improvement of 1.8% in the evaluated period (1989-1995). In this respect it should be mentioned that the chemical industries are responsible for approximately 60% of the total energy consumption as well as the energy savings in 1995. Results in this sector will highly influence the final results[2].

3   Effectiveness of VAs on Energy Efficiency

In the previous section it was concluded that the goals set out in the VAs are likely to be achieved. In the process of policy evaluation the concept of 'effectiveness' is an important additional assessment criterion. This concept studies to what extent the VA contributes to the goal achievement. In this paper the effectiveness of the VA policy is expressed as a percentage of the total achievement. According to Korevaar et al. (1997), because of a number of complications it is difficult to determine the actual effect of VAs on energy efficiency improvement or the amount of avoided CO_2 emission. In the first place it is not easy to distinguish the effect of VAs from the effects of other policy instruments. Secondly it is difficult to determine what would have happened without policy influence (the non-

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[2] In this respect it is regrettable that in this particular sector there are substantial discrepancies between the energy consumption data of VA monitoring reports and national statistics. This means that the conclusions for this sector must be regarded as only preliminary.

intervention case or autonomous development). Finally it is not always possible to distinguish energy efficiency improvement from structural changes. To overcome these problems three different methods for assessing the effectiveness of VAs are studied.

The following sub-section discusses an assessment method that uses a bottom-up approach to evaluate the effectiveness of VAs. The second sub-section elaborates on two assessment methods that use a top-down approach to develop a base-line scenario, which represents autonomous efficiency improvement. The third section compares the results of the three methods.

3.1   Assessment Method Using a Bottom-up Approach

The assessment method using a bottom-up approach assesses the effectiveness of the VAs by determining the energy savings of all conservation measures that can be attributed to the implementation of the VAs.

First of all this evaluation method requires an inventory of all the energy-saving measures taken in the sector to be evaluated and the amount of saved energy per measure since the introduction of the agreement. In the Netherlands' VA reports, the energy-saving measures are divided into five different energy conservation categories:

1) Good housekeeping/energy management
2) Replacement investments
3) Energy-saving investments (retrofit)
4) Combined heat and power generation (CHP)
5) Other measures

Glasbergen et al. (1997) estimated the contribution that these energy conservation categories made to the energy efficiency improvement in 9 industrial sectors on the basis of sectoral data. Energy-saving measures in each sector are classified in the above-mentioned conservation categories and energy savings in each category are aggregated. The aggregated results are presented in Table 1.

Table 1. Estimated contribution of energy conservation activities to energy efficiency improvement in the evaluated industrial sectors in the period 1989-1995

Conservation category	Total industries (%)	Total industries (PJ)
Good housekeeping	12%	5.8
Replacement investments	21%	10.4
Energy-saving investments (retrofit)	32%	15.6
CHP	20%	9.9
Other activities	16%	7.7
Total savings	100%	49.4

Source: Glasbergen et al. (1997)

According to Table 1 the total saved energy (compared to a frozen-efficiency level) in all the

evaluated industrial sectors amounted to 49.4 PJ in the period 1989-1995[3].

Not all energy-saving measures are taken primarily as a result of the energy conservation policy or the VAs on energy efficiency improvement. Within the process of policy evaluation it is however highly relevant to assess the degree to which the introduction of the saving measures has been stimulated by the implementation of the agreement. In our assessment model an energy-saving measure can be classified as a measure that has been fully stimulated, largely stimulated, considerably stimulated, stimulated to a slight extent or not stimulated. In general, the following guidelines are used for this assessment procedure.

- It is assumed that conservation measures in the category good housekeeping/energy management are fully stimulated by a VA, since these measures do not invoke excessive costs. Thus, the measures could have been taken anyway.

- Replacement investments are made for the extension or maintenance of the production capacity. They are not made primarily for the purpose of energy efficiency improvement. Therefore, these investments are considered as being stimulated to a slight extent.

- CHP investments are partly stimulated by VAs. However, for the most part these investments are stimulated by an agreement between the Dutch government and the energy distribution companies and by special subsidies directed towards the encouragement of CHP investments. Thus, it is assumed that CHP investments are stimulated by VAs to a slight extent and largely stimulated by the energy conservation policy (with the exception of VAs).

- Since measures in the category retrofit energy-saving investments require considerable investments and most of the time an adaptation of the production process, it is assumed that they are largely stimulated by VAs.

- The energy-saving measures in the category 'other activities' (e.g. close-down of firms, NO_x emission reduction) are assumed not to be stimulated by the VA.

It should be pointed out that energy-saving measures can also be classified as being considerably stimulated by a VA. For more details on this assessment procedure we refer to Glasbergen et al. (1997).

All the energy-saving measures taken in the industrial sectors evaluated are assessed according to the above-mentioned procedure. Table 2 shows the aggregated results of this assessment.

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[3] Here, it should again be noted that the chemical industries are responsible for approximately 60% of the total energy consumption as well as the energy savings. This means that the total results depend very strongly on the results in this sector.

Table 2. Aggregated energy savings in the evaluated industrial sectors divided into categories according to the degree of stimulation by VAs

Degree of stimulation	(PJ)	(%)
Not stimulated	10.3	21%
Stimulated to a slight extent	22.1	45%
Considerably stimulated	3.2	6%
Largely stimulated	6.8	14%
Fully stimulated	6.9	14%
Total savings	49.3	100%

Source: Glasbergen et al. (1997)

In order to determine the actual effect of the VAs on energy efficiency improvement more quantitatively a weighting scheme is used. The application of a weighting scheme provides a simple procedure for calculating the total amount of saved energy, stimulated by the implementation of VAs. Table 3 shows three different schemes, the average one (weighting scheme 1), the high variant one (weighting scheme 2) and the low variant one (weighting scheme 3).

Table 3. Weighting schemes

Degree of stimulation	Weighting 1	Weighting 2	Weighting 3
Not stimulated	0%	10%	0%
Stimulated to a slight extent	20%	30%	10%
Considerably stimulated	50%	60%	40%
Largely stimulated	80%	90%	70%
Fully stimulated	100%	100%	90%

Source: Glasbergen et al. (1997)

According to weighting scheme 1 for example 80% of the energy savings in the conservation categories classified as being largely stimulated are the actual effect of the VA implementation, et cetera. Table 4 presents an overview of the energy savings, which are the direct result of the VA implementation according to the three different weighting schemes. According to Table 4, 29-46% of the energy efficiency improvement can be attributed to the VAs, depending on the weighting scheme used.

Table 4. Overview of the energy savings stimulated by VAs, according to different weighting schemes

Weighting scheme	Stimulated savings (PJ)	Stimulated savings (%)
Scheme 1	18.3	37%
Scheme 2	22.6	46%
Scheme 3	14.4	29%

Source: Glasbergen et al. (1997)

The energy consumption in all the industrial sectors (excluding refineries) that contracted a VA on energy efficiency amounted 520 PJ in 1989. The energy consumption in the evaluated industrial sectors amounted to 420 PJ in 1989 and thus made up approximately 80% of the total energy consumption. Consequently, the total effect of the industrial VA policy in the Netherlands till 1995 can be estimated to have been 18-28 PJ.

3.2 Assessment Method Using a Top-down Approach

The method using a top-down approach assesses the effectiveness of a VA against a base-line scenario that represents the trend (business-as-usual) in the energy efficiency improvement. This trend scenario reflects the energy efficiency improvement in the absence of the VA and in the absence of additional policy instruments, apart from those already applied, (EEA 1997). Two different trend scenarios will be developed. The first business-as-usual scenario (BaU-I) assumes that autonomous energy efficiency improvement occurs at a fixed rate, e.g. 1.0% a year. The second base-line scenario (BaU-II) is calculated on the basis of a bottom-up technology database and an implementation model. The following section shows the assessment results of the VA outcome against the BaU-I scenario. The second sub-section deals with the calculation of the BaU-II scenario.

3.2.1 Business-as-Usual Scenario I (BaU-I)

This scenario reflects the energy efficiency improvement if no VAs on energy efficiency improvement had been signed. The BaU-I assumes a yearly autonomous energy efficiency improvement (AEEI) of 1.0% in the Netherlands. This scenario, assuming no VA policy, includes the energy efficiency improvement as a result of technological development. The AEEI of 1.0% is an average value for all the regions in the world (Grubb 1993)[4]. Figure 2 shows the monitored energy efficiency improvement in all the industrial sectors evaluated by Glasbergen et al. (1997) and the energy efficiency improvement according to the BaU-I. The difference between the monitored energy efficiency improvement and autonomous energy efficiency improvement can be considered as the energy efficiency improvement resulting from the implementation of VAs (depicted in Figure 2).

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[4] Grubb (1993) mentions that in several studies more optimistic values of 1.5% are used as well.

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Figure 2. Energy efficiency improvement in the evaluated industrial sectors according to BaU-I, monitored improvement and actual improvement by VAs
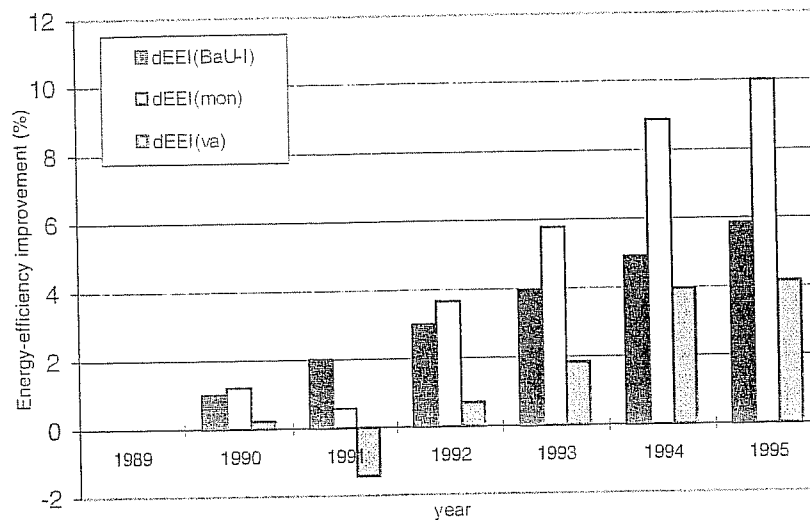

Figure 2 shows a decrease of the monitored energy efficiency in 1991. This decrease is due to a decline in the energy efficiency improvement in the chemical industry, which cannot be further explained. In subsequent years the energy efficiency steadily increases. In 1995 the energy efficiency improvement induced by VAs and the monitored improvement amount to 4.1% and 10.0% respectively. This means that about 40% of the total energy efficiency improvement over the period 1989-1995, that is 26 PJ in all the industrial sectors that contracted a VA in the Netherlands, can be attributed to the implementation of VAs.

The assumed autonomous energy improvement of 1.0% a year is a rough estimate, which causes large uncertainties in the results of the assessment method. Therefore the effectiveness is calculated again on the basis of an estimated autonomous energy efficiency improvement of 0.9% and 1.1% a year. Consequently the effectiveness of the VA policy over the period 1989-1995 can be assessed at 47% and 36%. It is obvious that the results of the assessment method are very sensitive to the autonomous energy efficiency improvement. A decrease or increase of only 0.1% in the autonomous energy efficiency improvement has a 5% effect on the final results. The actual uncertainty in the non-intervention EEI may be much higher than 0.1%, especially for short periods and single sectors.

3.2.2 Business-as-Usual Scenario II (BaU-II)

The autonomous amount of energy saved in the period to be evaluated (1989-1995) can be calculated on the basis of the technological energy conservation options available in a technology database and on the assumption that investments in these measures will really be implemented according to the implementation model. This means that the amount of saved energy is calculated when no additional policy instruments on energy efficiency were implemented. For the technology database we use ICARUS, developed by De Beer et al. (1994). Simple implementation models as used in Farla & Blok (1998) and De Beer et al. (1995) will be used. At a later stage a more advanced model as described in Gillissen (1995) can be used.

Industrial potential for energy conservation

The pay-back period (PBP) is an important investment criterion for companies. A simple PBP is calculated by dividing the total investments by the annual revenues. The PBP can be defined as follows:

$$PBP = \frac{Total\ investments}{Net\ annual\ revenues} = \frac{I}{SPEC - OM}$$

(5)

Where:

I = investments costs (Dfl/yr)
$SPEC$ = annual saved energy purchase costs (Dfl/yr)
OM = annual operation and maintenance costs (Dfl/yr)

With the ICARUS database the potential for energy conservation according to this investment criterion can be calculated. In Figure 3 the cumulative energy efficiency improvement (CEEI) in the period 1990-2000 is plotted against the PBP. The CEEI is a measure of the EEI expressed as a percentage instead of an index. The CEEI in Figure 3 constitutes the aggregated value of the sectoral potentials for industrial energy efficiency improvement. The energy efficiency improvement achieved by CHP investments is included in the calculations as well. For the calculations the European Renaissance scenario and a high-energy price scenario were selected. A value of 40% was used for the average efficiency of power plants in the year 2000.

Figure 3. CEEI in the industrial sector as a function of the PBP
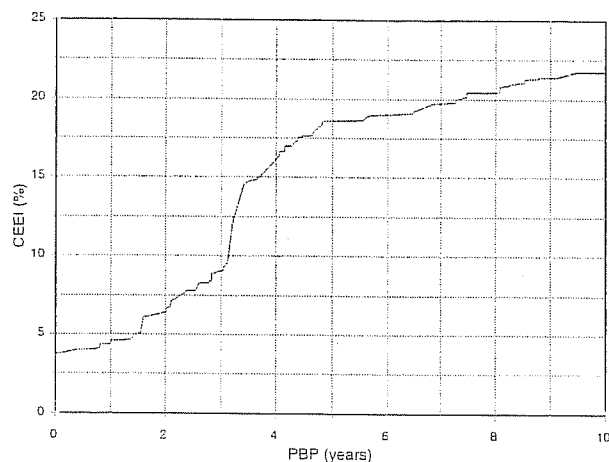
We calculate a maximum saving potential of 28% in all the industrial sectors collected in the ICARUS database.

Adoption of technological potential energy conservation measures

The implementation model indicates the percentage of firms willing to make a profitable investment with a given maximum pay-back period (PBP). In Table 5 and Error! Reference source not found.6 implementation models used in the calculations are presented. The models are different interpretations of basic survey data collected by Gruber & Brand (1991) and Koot et al. (1984). The tables show the relation between cut-off pay-back periods and the adoption of technological potential energy conservation measures according the implementation models. Table 5, for instance, indicates that 95% of the firms would adopt an energy efficiency

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technology with a PBP shorter than 1 year.

Table 5. Implementation model I

Implementation model II Pay-Back Period (year)	Adoption (% of technical potential)
<1	95
<2	80
<3	55
<4	30
<5	10
>5	0

Source: Farla & Blok (1998)

Table 6. Implementation model II

Pay-Back Period (year)	Adoption (% of technical potential)
<2	100
<3	86
<4	56
<5	39
>5	15

Source: de Beer et al. (1996)

The implementation model is applied as follows. In the electronic database, ICARUS, the total investments with a specific PBP are set equal to the corresponding adoption percentage in Table 5 and Table 6. If the projected energy saving potential of the investment options with a PBP of 1 year is known, the autonomous energy saving can be calculated. The difference between the total energy savings monitored and the calculated savings is regarded as the actual outcome of VAs on energy efficiency improvement.

Effectiveness
The autonomous energy efficiency improvement in the period 1990-2000 is estimated at 9% using implementation model I and at 15% using model II. This means an estimated annual average improvement for models I and II of 1% and 1.6% a year respectively. Thus, using linear interpolation between 1990 and 2000 we estimate the autonomous energy efficiency improvement between 1989 and 1995 to be 5.7% to 9.1%. Comparing these figures with the monitored efficiency improvement the effectiveness of the VA policy in 1995 can be assessed at 9%-43%.

Note that in this case too there are uncertainties, both with respect to the technology database and the implementation models. In the latter case, it should be clear that there are barriers other than the profitability barrier that is modelled (e.g. lack of knowledge, lack of interest in energy efficiency investments). Here we also want to point to the suggestion of Korevaar et al. (1997) that these are exactly the barriers that are attacked by the VAs.

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3.3 Comparison of Results

In this section the results of the three assessment methods evaluating the effectiveness of the VAs are compared. In Table 7 the effectiveness of the industrial VAs according to the three methods is listed.

Table 7. Effectiveness of the industrial VAs on energy efficiency in the Netherlands

Assessment method	Effectiveness (%)	Saved energy (PJ)
Bottom-up	29-46%	18-28
Top-down (BaU-I)	36-47%	22-29
Top-down (BaU-II)	9-43%	6-26

The three assessment methods show comparable results, although there is a large range of uncertainty. The effectiveness of the VA policy is likely to be 25-45%.

Further research is required to improve the evaluation methods and make a more precise assessment of the effectiveness.

4 Efficiency of VAs

The efficiency evaluation of VAs requires an assessment of the financial input and the stimulated savings. In the previous section the benefits of the industrial VAs were calculated. In this section we will first focus on the investments in energy conservation technologies made by firms. Secondly government spending for the preparation and implementation of VAs will be presented.

Industrial investments
To estimate the total industrial investments it is assumed that the energy conservation investments and the investments in CHP (see categorisation in section 3.1) are the most important. Secondly, it is assumed that conservation measures in other categories (good housekeeping, replacement investments and other measures) do not require important additional investments. In the period 1989-1995 energy conservation investments in the Netherlands saved about 16 PJ in the industrial sectors evaluated. From the evaluation and from the other sources (see also Figure 3) it is clear that the pay-back time of most measures is short. Assuming an energy price of 6-8 fl/GJ and a pay-back period of 2-3 years, the total investments are estimated at 190-300 Mfl (Glasbergen et al., 1997). According to Senter (1996) the costs of the installed CHP plants amount to 1343 Mfl. In addition, the energy distribution sector spent 800 Mfl on CHP plants (Senter 1996). It can be concluded that industry has not been put to great expense as a result of the VAs.

Government spending
In the Netherlands the energy agency, NOVEM, is to a great extent responsible for the implementation of the national energy conservation policy. Table 8 lists how much the government spent on the preparation and implementation of the industrial energy conservation policy.

Table 8. Government spending on industrial energy conservation in the period 1989-1995

Financial Mean	Financial input 1989-1995 in Mfl
Novem-subsidy programmes (TIEB, EMA)	167
Novem-Industrial sector programmes (BSE, MJA)	131
Novem-staff	36
CHP-subsidies	202
Total governmental financial input	536

Source: Glasbergen et al. (1997)

The TIEB and the EMA are subsidy programmes aimed at the stimulation of new energy-saving technologies in industry and research into new potentials for energy conservation respectively. The BSE and MJA are subsidies aimed at the support of specific industrial energy conservation projects and expenditure on external consultants respectively.

Table 9 gives overview of the specific CO_2 emission reduction investment costs and specific investments for energy savings in the industrial sector. These costs are based on the CO_2 emission avoided as a result of the industrial energy conservation policy in the Netherlands and government spending (see Table). The specific investments are the initial costs of annually returning energy savings or emission reductions.

Table 9. Overview of specific investments of the energy savings and the CO_2 emission reduction

		Total policy	Industrial VAs	CHP policy
Energy savings	PJ	25-36	18-29	7
Avoided CO_2 emissions	Mton CO_2	2.0-2.8	1.3-2.1	0.7
Spec. Investments for energy savings[*]	Dfl/GJ	15-21	12-19	29
Spec. Inv. for CO_2 emission reduction[*]	Dfl/ton CO_2	190-270	160-260	290

[*] Specific investments are the initial costs of annually returning energy savings or emission reductions.
Source: Glasbergen et al. (1997)

The cost-efficiency of VAs can be compared with specific CO_2 emission reduction costs of other policy instruments, like for instance the 'energy bonus', a large-scale subsidy scheme that existed between 1980 and 1988 for stimulating investments in energy efficiency improvement. Farla & Blok (1998) estimated the specific CO_2 emission reduction investments to be 550 Dfl/ton CO_2, that is 40 Dfl/GJ. Here it should be noted that only direct effects of the energy bonus were taken into account; indirect impacts of this subsidy were not included. These figures suggest that from the government point of view, the VAs are a cost-efficient policy instrument for the improvement of energy efficiency, at least compared to a subsidy instrument.

5   Discussion and Conclusion

In this paper several industrial VAs on energy efficiency improvement in the Netherlands have been evaluated. The energy efficiency index was introduced as an indicator to study the energy efficiency improvement in the industrial sectors. However, many industrial sectors do not adopt the general approach for monitoring energy efficiency. Transparent procedures for the monitoring of the energy efficiency are therefore required. With respect to the goal achievement of the VAs it can be said that on the basis of the average annual energy efficiency improvement over the last six years, the goals set out in the VAs can be reached if some additional efforts are made in the years to come. In the industrial sectors evaluated the calculated average annual energy efficiency improvement amounted to 1.7% in the period 1989-1995. Consequently the projected energy efficiency in 2000 will amount to about 18%, which is slightly lower than the goals set out in the VAs. It is however necessary to keep in mind the uncertainties in these figures. These uncertainties are due to discrepancies in energy consumption data of the chemical industries between VA monitoring reports and national statistics and are due to the relatively large contribution made by the chemical industry to the total industrial energy consumption.

The three methods of assessing the effectiveness of VAs show a wide range of uncertainties in the results. Regarding the assessment method using a bottom-up approach, the uncertainties in the actual outcome are caused by the subjective process of classifying the energy conservation measures in categories and the uncertainties in the weighting schemes. Further research on the actual investment behaviour of firms (e.g. by interviews with individual firms) should improve the classification and the weighting schemes.

Uncertainties in the business-as-usual scenario-I can influence to a great extent the results of the assessment method using a top-down approach. It is shown that the effectiveness or the actual outcome of VAs is very sensitive to autonomous energy efficiency improvement. The actual uncertainty in the non-intervention energy efficiency may be much higher than the assumed 0.1%, especially for shorter periods and single sectors. An alternative source for non-intervention EEI figures may be national models that are, for instance, based on economic analysis. However, careful analysis of the origin of such figures is necessary before they can be used.

With respect to the implementation model applied in the third assessment method, it should be noted that there are several investment barriers besides the profitability barrier, which have not been modelled. Secondly, it can be argued whether an interpolated function representing the relation between the pay-back period and the adoption of technological potential energy conservation measures should be used in stead of the cut-off pay-back periods used in our implementation models. The uncertainties in the technology database and its effect on the actual outcome of the VAs cannot be assessed within the scope of this paper.

The results of the evaluation of effectiveness lead to the preliminary conclusion that about 25-45% of the achieved energy efficiency improvement can be attributed to the implementation of industrial VAs. This percentage takes into account a large range of uncertainties and means that the industrial VAs enhanced the rate of energy efficiency improvement by more than 50%.

Due to the variety of financial regulations and subsidy schemes promoting energy conservation, it is quite difficult to assess government spending on the preparation and

implementation of the VA policy on industrial energy efficiency improvement. On the basis of our rough estimate we suggest that compared to a subsidy instrument the VA policy is relatively cost-efficient.

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Long Term Agreements on Energy Efficiency in Industry

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Synopsis

Dutch industrial sectors agreed to improve their energy efficiency by 20% over the period 1989-2000. Results show that they have made fair progress and that savings outweigh the investments substantially. In 1997 the LTA's have been evaluated extensively. The overall judgement was positive. Distinct items for improvement were indicated. Most parties express the intention to continue along the same track in the period after the year 2000. Where the most obvious measures have been taken, the contents of the agreements will probably change. This is now subject of discussion between industry and the Ministry of Economic Affairs.

Abstract

Over the past years a particular version of Voluntary Agreements has been developed in the Netherlands. These agreements focus on energy efficiency: "Long Term Agreements on Energy Efficiency" (LTA's) and are strictly monitored. This type of agreement was first applied in sectors of industry. Later on it also found its way to the services and commercial sectors. LTA's are primarily agreements between the government (Ministry of Economic Affairs) and representatives from economic sectors. The process to come to an LTA usually takes a few years. Once it is effective, it puts energy efficiency into focus in many individual companies. A variety of activities are undertaken to improve the sector's energy efficiency. As LTA's focus on particular sectors, they are (in content) highly dedicated to the characteristics of the sectors.

In this program different parties agree to pursue the same target, although their primary motives may be different. Government primarily aims for an emission reduction of carbon dioxide, while industry primarily is driven by cost benefits and the expectation that future regulation can be prevented by active participation. About 90% of industrial energy consumption is covered by LTA's.

An intensive monitoring process assures that achievements are made visible. From this monitoring we see that in the year 1996 the energy efficiency improved by 12.5%, with respect to the reference year 1989. This meets the expectations of the program. The related CO_2 emissions however showed an increase instead of a reduction. The main reason for this is the economic growth over recent years that turned out to be higher than anticipated when the LTA framework was set up.

In the year 2000, annual savings of about 1500 million Guilders for the Dutch industry are anticipated. This implies that the Dutch industry improves its performance compared with international competition. The LTA's offer a framework that also looks promising to be continued after expiration of the first target-year (2000). As the most obvious measures for energy improvement have been taken, new themes will probably be addressed. This is now subject of discussion between industry and the Ministry of Economic Affairs.

1 Introduction

Voluntary Agreements (VA's) are a powerful instrument to stimulate developments in national societies into a socially desirable direction. An environmental VA may broadly be defined as:

> *An agreement between government and a sector in the national economy to facilitate voluntary action with a desirable social outcome, encouraged by the government. This action is undertaken by the participant, based on the participant's self interest.*

In the Netherlands a special version of VA's is developed over the past years: Long Term Agreements on Energy Efficiency (LTA's). In these LTA's, sectors from industry (and services and commercial sectors) agree to improve their energy efficiency over a range of years, to meet a set goal in the year 2000. In this case the government is represented by the Ministry of Economic Affairs. Novem—as a Government Agency—supports the process, assists the sectors and controls the monitoring.

1.1 Background

The National Environmental Policy Plan (1989) formulates the national policy for reduction of the emission of greenhouse gasses. The national target is a reduction of CO_2 emissions by 3 to 5 percent, in the year 2000, compared to the 1989 level. One of the means to that goal is the Long Term Agreements on Energy (LTA's). Reduction of energy consumption is seen to be largely congruent with reduction of CO_2 emissions, as by far the largest part the energy supply is based on fossil fuels. For other greenhouse gases, like methane and PFC's, other policy instruments apply to achieve reductions. The main regulatory instrument is The Environment Law that sets the framework for permits on industrial operations. Against this background the policy goal of the LTA's is to stimulate energy efficiency beyond existing trends, in a context of low energy prices, without resorting to new regulations.

1.2 Scope

The first LTA's were signed in 1992 and as of 1 January 1997, the status is:
- 31 LTA's with industry associations;
- about 1000 industrial companies participate within LTA's;
- over 90% coverage of industrial primary energy consumption;
- target for energy efficiency improvement over the period 1989-2000 is 20%;
- by the end of 1996 the energy efficiency improvement actually came out at 12.5%;
- LTA's with groups of users in services sectors.

2   Methodology

Participants and process

Prior to the signature of an LTA, the feasibility of the target to be specified in the agreement is assessed. Potential signatories are consulted to check their willingness to participate in such an agreement.

In general the following steps lead to signature:

1) The government agency (Novem) approaches the industry for a preliminary assessment of its energy efficiency potential.
2) The industry association develops a Letter of Intent to undertake energy efficiency improvement, addressed to the Ministry of Economic Affairs.
3) Novem makes an inventory of economically viable measures (acceptable pay back period) that can be undertaken in major companies within the industry association. This provides the basis for the target for energy efficiency improvement.
4) The LTA is signed by the industry association, the ministry of Economic Affairs and Novem. Individual companies express their participation by accession letters.

The measures needed to achieve the objectives of an LTA are set out in the "Long Term Plan for Improvement of Energy Efficiency". This plan is the basis for the LTA. It must be flexible to respond to unexpected developments in market economics and technology.

A Long Term Plan starts with a description of the concerned sector and the role of energy within that sector. It includes:

- assessment of energy consumption in 1989, as "reference year";
- survey of opportunities for energy efficiency improvement;
- drafting of company energy plans;
- monitoring and energy management in each company;
- research and development on new low-energy technologies;
- demonstration projects for energy savings measures;
- market introduction of low-energy techniques;
- assistance to individual companies;
- transfer of know-how and information.

Commitments/Targets

The average target of LTA's is a 20% increase in energy efficiency by the year 2000, from 1989 levels. The signed LTA specifies the commitments of both Government and industry, including objectives, targets and how measures can be implemented. The government agrees not to introduce other regulations on energy efficiency in industry, and the industry voluntary agrees to reduce its energy intensity.

The document signed by the parties starts with a recognition of the greenhouse issue and of the national objective of CO_2 emissions stabilisation in 1995 at the 1989 level, and a reduction by 3-5% in the year 2000. Based on the memorandum on Energy Conservation, the objective for industry is a 20% improvement in energy efficiency by the year 2000, from the 1989 level.

Each LTA is a contract under civil law and it is target based[5].

Defining energy efficiency

The energy efficiency targets are defined as a percentage improvement in overall energy efficiency within each participating industry sector (with individual companies contributing different amounts to the target). The definition of Energy Efficiency Index is:

> *The energy consumption in the year in question to produce the total output in that year, divided by the energy consumption that would have resulted had the same production been made with the energy efficiency in the year of reference (1989).*

For electricity consumption the primary input to electricity production is taken. The efficiency of electricity generation is assumed to be 40%. Reducing final consumption of electricity by a certain amount thus contributes more to the energy efficiency of a plant than saving the same energy amount of natural gas.

This method creates an incentive to use co-generation, to fully utilise the primary energy content of fuels. Calculation of the energy efficiency improvement excludes energy-carriers used as feedstock (non-energetic use) as these are volume related and not directly related to energy efficiency. Furthermore feedstock usually does not directly contribute to CO_2 emissions.

Production is defined differently for different sectors. In many industries, a stated weight of product can be used as an indicator, where little product change is expected until the end of the decade. In a second method the energy consumption per process step is taken as the basis for energy-efficiency (refineries). Each plant determines the energy requirements of specific process steps. Changes in energy requirements which might be considered "structural" (for example, purchase of intermediary products previously manufactured within the plant) are separated from those which are purely efficiency based.

As part of the LTA's broad areas of action to improve energy efficiency are noted. Indicative contributions are made from measures such as energy management, combined heat and power, improved power generation, heat integration and modernisation of processes.

Commitments of the signatories and termination

The commitments of the signatory parties vary from one agreement to another, depending on the specifics of the sector. Companies agree to work out an energy efficiency improvement plan, and improve energy efficiency as far as is practically and economically achievable, to contribute to the industry target.

Energy efficiency improvements don't have to be distributed equally among different sites of a same company. New facilities for instance usually show a better overall energy efficiency than older ones. This clause is not straightforward as provinces and municipalities have the authority to impose requirements to obtain operation permits, including energy efficiency requirements. Signatories to an LTA are considered to be in compliance with permit requirements concerning energy efficiency.

An energy-saving plan and annual monitoring reports are mandatory for each company.

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[5]Target based LTA's comprise negotiated targets that are legally binding and which pre-empt future regulatory requirements, or are tied to a strong regulatory threat.

Failure to provide one or the other is a valid reason to exclude that company from the LTA. The company will then be subject to normal existing regulations. When an entire sector fails to meet the goal as agreed, and is not able to give a suitable explanation, the sector LTA as a whole can be terminated.

The industry association must actively support energy efficiency improvements among its members. It develops programs to that end, with the overall sector energy efficiency target as goal.

Government commitments/actions
The Minister of Economic Affairs agrees to provide support to the program, including:

- Financial instruments aiming at industry: tax abatement can be granted if investments in energy-efficient (or clean) technologies are realised. This scheme, however, applies to all companies, whether they are signatories to an LTA or not.
- Financial assistance within the framework of LTA, including various subsidy schemes.
- Increase of the above financial assistance if the programme is more promising than expected.
- Support in the form of a detailed audit of the industries' facilities. This includes an inventory of energy consuming equipment within plants, the specification of how energy is used, and the identification of cost-effective energy-efficient investments.
- Coordination of regulatory measures aimed at energy efficiency in industry, including requirements to obtain permits and energy taxes.

The government assures consistency and protection from new regulations aimed to improve energy efficiency. It also provides financial and technical support in exchange for voluntary participation.

Each agreement specifies that if significant policy changes were to occur before 2001, the parties may consider revision of the contents of the agreement. The contract may be terminated by either party if no consensus is achieved.

LTA's and other energy policy measures
- In 1994 the government decided to cut the subsidy on co-generation. Industry has not shown a desire to step out of the agreements in response to the cut in this subsidy scheme.
- In 1996 the government introduced a so-called carbon-tax. This tax is bound to a limit such that most industries are hardly affected. Nevertheless industry demonstrated great difficulty to accept this new tax..
- The government in turn introduced a new tax abatement scheme for energy efficiency investments (effective 1 January 1997).

Time period
- Work on LTA's started in 1990, with the first agreement signed in May 1992 (iron and steel industry). Negotiation of an agreement typically takes one to two years, from the letter of intent to signature.
- In the early years, some industries felt that the period until the year 2000 was too long, prone to too many uncertainties to be covered by an agreement. So they set intermediate targets for the year 1995. Being open to international markets, industry is

reluctant to sign an agreement with a real long term target.

- This partly explains why an agreement on absolute CO_2 emissions might not be reached: industry sectors would have to forecast their growth over a relatively long period.
- The main reason to refuse an agreement on absolute CO_2 emissions is of course that industry is not prepared to restrict the production volume when market demand grows.

Monitoring and reporting

Each year, companies must report to government on the previous year's energy efficiency index, the amounts of energy purchased and net primary energy used, including a survey of corrections (if applied) for:

- energy to meet more stringent environment, safety or health requirements;
- changes in energy consumption to meet changed product specifications;
- changes in energy consumption due to change in manufactured or purchased intermediary materials.

These three items, represent changes not driven by energy efficiency. They are eliminated from the calculation if specified in the LTA and agreed by all parties. Actually these corrections do amount to not more then a few tenths of a percentage-point.

An annual report is prepared by representatives of all signatories to make the progress public. This and other forms of publicity inform the public and provide recognition for industries that successfully improve their energy efficiency.

Novem supports this process as an independent agency, and assures quality and objectivity of the figures produced.

3   Results

As of January 1st, 1997, 31 LTA's are effective in industry sectors and 6 in the services sectors. 9 LTA's are concluded later than 1994. Based on monitoring reports from 29 LTA's the average Energy Efficiency Index (EEI) in 1996 turns out to be 87.4%. The 29 LTA's from which monitoring reports are available cover more than 80% of the industrial energy consumption. The figure below shows how the EEI develops over the years.
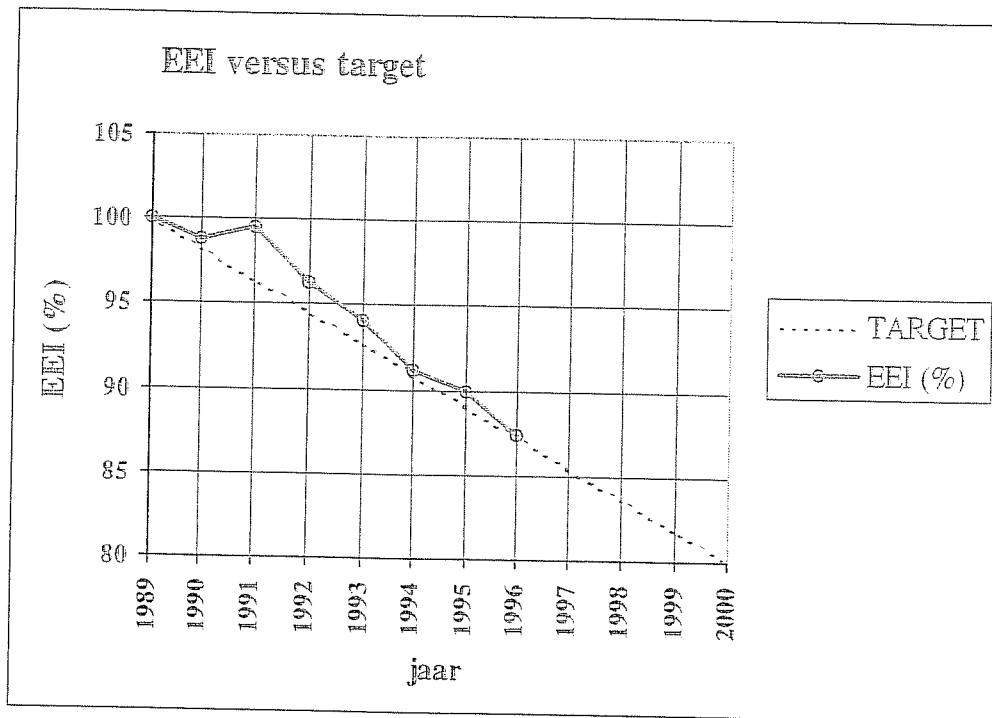
Figure 1. Course of Energy-efficiency Index (EEI) over past years, actual value (from monitoring) versus target.

From this we conclude that actual energy efficiency in the industry is developing according to the targets set for the year 2000. In terms of CO_2-reduction however, the target is missed. Instead of a reduction in CO_2-emission, actually an increase was observed. The main reason for this deviation is a higher volume growth than anticipated at the time that the framework for LTA's was worked out.

Industry sectors demonstrate a positive perception of the LTA approach. In an evaluation they expressed their support to the approach and until now no sector stepped out of an agreement. This opens the perspective to continue along the track, after the original target date (the year 2000) expires. The contents of the agreements can be adapted, the basic mechanism stays the same.

The impact on economy can be assessed globally. An improvement of energy efficiency of 20% on primary energy input to the industry yields a saving of about 150 PJ. With present price levels for energy, this represents a value of about 1,500 million Guilders. These savings from the national economy will repeat each year, from the year 2000 onwards. A rough estimation of total costs over the period 1989-2000 shows that the savings outweigh the costs by far. The figure below shows a rough input/output model, in terms of costs/benefits.
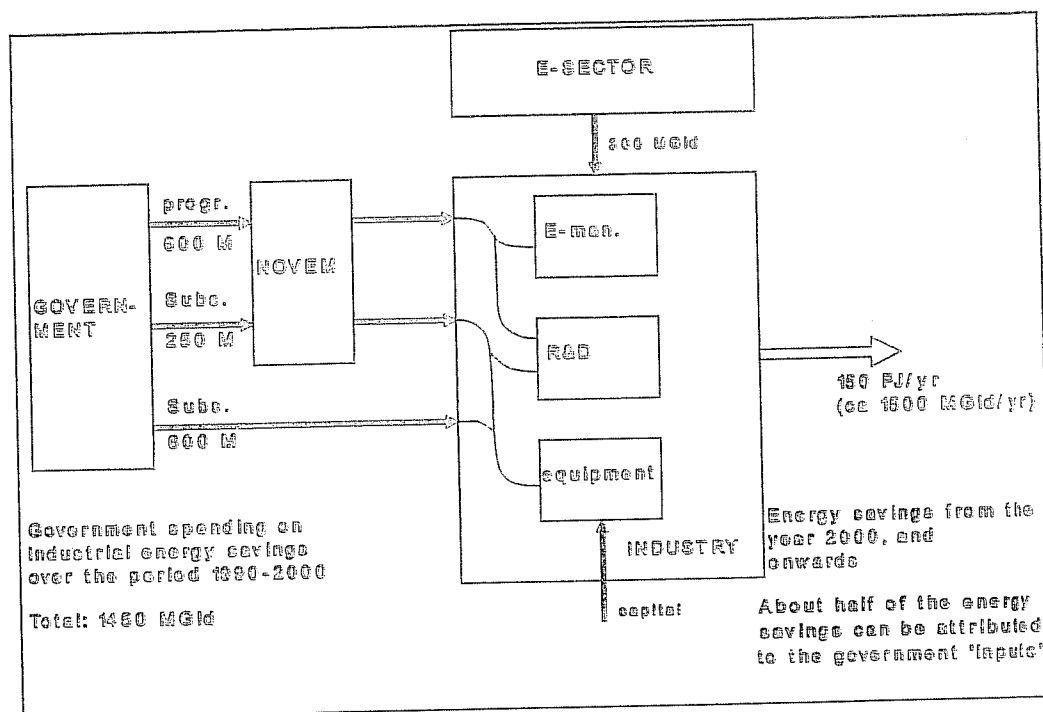
Figure 2. The LTA process seen as an input/output box

The table in section 7 gives an overview of all the sectors participating in LTA's in the Netherlands.

4   Evaluation

In 1997, the University of Utrecht made an extensive evaluation of the LTA's. The main conclusions can be summarised as follows:

- Participation in LTA's generates more management attention for the energy situation in companies.
- Participating companies become more aware of existing opportunities for energy saving.
- Consequently, the exploration of the existing potential is accelerated.

Also various points for further improvement were indicated:

- Quality and role of Energy Savings Plans needs to be improved
- Procedures need to be more uniform (energy savings plans, monitoring)
- Targets could have been more ambitious
- More focus on long term developments
- Role of subsidies not to be overestimated
- Room for extension with other themes (more indirectly related to energy)

Based upon the positive assessment of the LTA's and the valuable recommendations, most parties expressed the desire to continue with the framework of LTA's, taking into account that

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new elements are to be added and some (mainly procedural) improvements need to be implemented.

5   New Generation LTA's

The new generation LTA's will span the period 2000-2010. As the most obvious measures for energy efficiency have been taken in the first period, the range of themes is extended with new ones. They can be grouped into three categories:

1) Process efficiency
2) Product efficiency
3) Industrial co-operation

In the category Process efficiency, themes like 'process synthesis', 'new technologies', 'product waste reduction', 'internal logistics' and 'reduction of feedstock' are addressed. This category is close to the energy-efficiency items in the current LTA's, with the exception of feedstock reduction.

In the second category more new themes are included, like: 'de-materialisation', 'renewable materials', 'low energy product design' and 'new product technologies'.

Industrial co-operation covers the cross-boundary themes, like: 'transport', 'recycling', 'chain-management' and 'sustainable industrial areas'. Sustainable energy is considered a separate theme.

A very global assessment reveals that over all industry sectors a total saving of more than 300 PJ is possible, on a total of roughly 1400 PJ (in the year 2000). Each sector is challenged to see which themes they are able (and willing) to address in the period 2000-2010. Then a quantified target needs to be set. When the sum of al the targets comes close to the national target, this will be a basis for a new LTA. From this it will be clear that the monitoring process will be substantially complicated. Nevertheless parties are convinced that also this problem will be solved.

By the end of 1998 the first indicative figures will be available. By the end of 1999 the new agreements have to be prepared for signature.

6   Conclusions

The implementation of "Long Term Agreements on Energy Efficiency", as developed in the Netherlands, appears to work out well. Energy efficiency develops according to expectations and no contract has been terminated. CO_2 emissions are reduced substantially with respect to what they would have been when the same production would have been made with the 1989 energy efficiency. Volume growth however leads to a limited growth in absolute CO_2 emissions. Dutch industry continues to improve its performance and becomes more competitive. Energy cost savings outweigh the funds that the government makes available within the framework of LTA's.

The intention from most parties involved is to extend this approach into the period 2000-2010. New themes to be addressed are indicated and industry is challenged to indicate which themes

they will work upon in that period and what the saving will be over that period. By the end of 1999 a clear view will be available of what can be achieved by the different sectors.

7   Tables

Table 1: sectors participating in the Dutch LTA's

LTA-SECTOR NR LTA	Prim. Energy Cons. (PJ) (CBS. '89)	% Target Energy Efficiency Impr. (year 2000)	Date LTA Concluded (yr./month)	Settlements
Meat processing	5.8	20	93/09	70
Vegetable and fruit processing	3.0	20	93/10	29
Potato-processing industry	0.5	20	96/06	18
Margarines, fats, oils	7.6	22	93/06	27
Diary industry	18.1	20	94/07	86
Sugar industry	8.7	20	93/09	5
Coffee-roasting industry	1.5	15/20	94/05	12
Breweries	4.0	18	93/10	17
Soft drinks industry	1.0	20	96/07	7
Building ceramics industry	8.8	20	93/10	55
Fine-grained ceramics industry	3.1	20	94/04	19
Asphalt industry	2.5	20	95/11	57
Calcium-silicate brick industry	1.2	20	92/11	11
Cement industry	11.0	20	92/07	3
Glass industry	11.1	20	92/07	7
Philips	10.8	25	93/05	62
Chemicals industry	310.0	20	93/11	111
Oil refineries	161.2	10	95/09	5
Oil and gas production	39.0	20	96/06	12
Textile industry	8.2	20	92/10	49
Paper industry	33.5	20	93/05	30
Rubber processing industry	2.2	20	94/11	25
Plastics processing industry	10.2	20	94/12	78
Iron and steel industry	58.5	20	92/05	2
Non-ferrous metals industry	8.0	15	93/10	21
Iron foundries	2.0	16	95/06	24
Surface treatment	1.5	20	96/03	147

Industrial washing	1.7	20	94/06	66
Refrigeration and cold storage	2.2	28	96/03	87
Carpet industry	1.0	20	96/06	15
Large individual companies	14.5	20	97/03	139
	1296			752.4
Health care sector	27.0	30	94/06	800
Secondary Vocational Education	4.0	30	94/12	450
Higher Vocational Education	2.0	30	96/02	250
Banking Sector	6.0	25	96/12	3500
Royal Dutch Airlines (KLM)	1.0	28	94/10	1
Amsterdam Airport	1.0	28	94/11	1
	41.0			5002
	6298			793.4

III. Information, Monitoring and RD&D Programs

Evaluation of the Former EADC Program

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Abstract

The United States Federal Government has been funding industrial energy audits for small and medium sized manufacturing firms under the auspices of the Energy Analysis and Diagnostic Center/Industrial Assessment Center program since 1976. The program, now called the Industrial Assessment Center program, is funded out of the Office of Industrial Technology of the US Department of Energy. A component of the National Energy Strategy, the IAC program is major energy conservation, waste minimization/pollution prevention, and productivity enhancing initiative of the U.S. Department of Energy (DOE). The assessments are performed by teams from engineering schools at universities, which are made up of faculty and students. Normally the team performs a one-day site visit at an industrial plant, which follows an extensive pre audit data gathering function. Following the site visit the audit team prepares a report for the manufacturer which includes information about the plant's energy use, processes and other operations. In addition, each report has several assessment recommendations (AR's) which are written up with sufficient engineering design to provide for anticipated savings, implementation costs and simple payback for each AR presented. This service provided to the manufacturer at no cost.

The program has been a benefit to more than the manufacturers served. The students involved in the program have a unique opportunity to see a range of manufacturing operations first hand. This results in both more motivated students who more often than not enter energy management as a career field. Faculty have developed ideas for research from their studies of manufacturing processes and have taught courses using experiences gained through their auditing work. The government invests in the program, but through the direct support to small and medium sized manufacturers (which, in theory, become more profitable through increased energy efficiency and therefore pay more taxes) they are able to recover those costs and in the process underwrite the program!

One additional benefit from the program is that the data generated by the assessments provides a unique opportunity to quantify the state of energy management and pollution prevention in small and medium sized industry and the potential of auditing to improve efficiency. Since 1980, the data has been compiled from the assessment performed under this program. The results through the present are currently available via the Internet through the Office of Industrial Productivity and Energy Assessment at Rutgers University.

1   Background

1.1   History of EADC/IAC

The U.S. Department of Energy (DOE) has been funding industrial energy assessments for small and medium sized manufacturing firms since 1976. In October 1995, the centers were tasked to perform only industrial assessments and the name of the program officially changed to the Industrial Assessment Center program. At this time, each center was required to target waste streams in addition to the traditional energy streams. Following a training session in August 1996, the centers were then required to incorporate productivity enhancements in the reports. These types of recommendations look at ways to increase pieces produced per hour or to decrease cost per piece produced. The energy audit has since grown into an integrated industrial assessment.

Charles Glaser of the Office of Industrial Technologies directs the IAC program. Field management of the program is carried out at two sites: the University City Science Center in Philadelphia and Rutgers University. Each field manager oversees the operations of one half of the centers. This involves all aspects of quality assurance; reviewing reports, monitoring contract compliance, providing program support. In addition, Rutgers University is charged with the responsibility of maintaining data generated by assessments carried out at all of the centers. Teams of faculty perform the assessments and students from accredited engineering schools at universities and have resulted in more than 7,700 assessments and 53,000 recommendations.

The IAC program is very specific about what plants qualify for an assessment; it is directed at the small to medium sized manufacturers. Large manufacturers are expected to be able to fund such studies independently, through the consulting industry, and the scope of the assessment being necessarily limited would result in an unacceptably sketchy review of plant operations if large plants were selected as clients. The assessment is available for all types of manufacturing provided the plant's products are within the Standard Industrial Classification codes 20 through 39 and the facility is located within 150 miles (242 kilometers) of the host campus. The plant must also meet the following criteria:

- Have gross annual sales of $75 million US or less
- Consume energy at a cost of $1.75 million US per year or less
- Employ no more than 500 people
- Have no technical staff whose primary duty is energy analysis

Thirty universities currently contribute to the IAC program. Of these 30 schools (listed in Table 1), 26 are major state universities and four are private institutions. Schools become active program participants via response to an open solicitation of all ABET accredited universities with engineering programs. The current IACs are located strategically around the country:
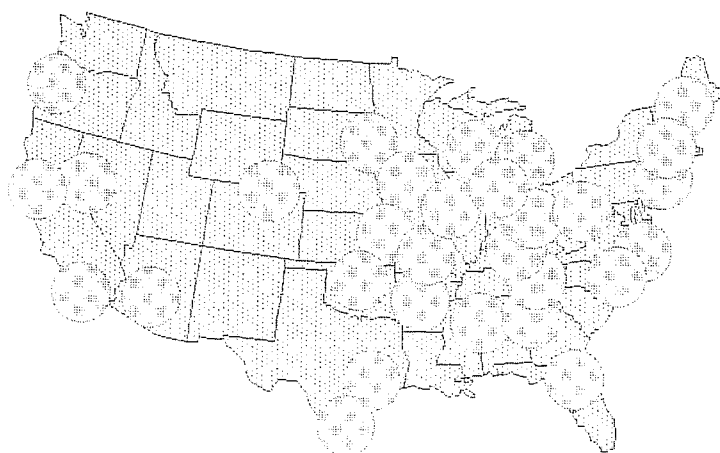
Figure 1. Location of IACs in the US

Table 1. Schools with Established IAC's

Arizona State University	South Dakota State University
Bradley University	Texas A&M University–College Station
Colorado State University	Texas A&M University–Kingsville
Georgia Tech	University of Arkansas–Little Rock
Hofstra University	University of Dayton
Iowa State University	University of Florida
Kansas University	University of Louisville
Mississippi State University	University of Maine
North Carolina State University	University of Massachusetts
Notre Dame University	University of Michigan
Oklahoma State University	University of Missouri–Rolla
Old Dominion University	University of Nevada–Reno
Oregon State University	University of Tennessee
San Diego State University	University of Wisconsin–Milwaukee
San Francisco State University	West Virginia University

1.2 Current Program Accomplishments

Beginning with four universities in 1976, the IAC program has 30 universities performing 25 assessments each year. This type of frequency allows both faculty and students to remain on the forefront of new technologies in the energy efficiency and pollution prevention arena. Since the inception of the program, more than 2,000 students have participated in performing an industrial assessment. The experience gained from working in an IAC allows these students to become more marketable when pursuing a career following graduation.

1.2.1 Client profile

Using the database developed from the assessments, the characteristics of the clients served by the IACs can be studied. Figure 2 shows a histogram of assessments as distributed through the various manufacturing SIC codes. The distribution is not even, which is to be expected. Certain industries, such as food processing (SIC 20) or fabricated metals (SIC 34), have a much higher presence in small and medium sized manufacturing operations than the pulp and

paper industry or petroleum refining.
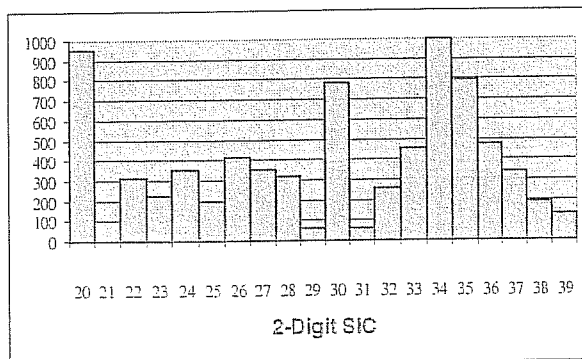
Figure 2. 2-Digit SIC Profile of Clients Served

Figures 3 and 4 show the distribution of gross sales and number of employees for the clients served in the IAC program. The most typical plant has about 100 employees and on the order of $6 million in annual gross sales. This is well under the limits described above, but represent an ideal sized operation for the scope of assessment envisioned by the program.
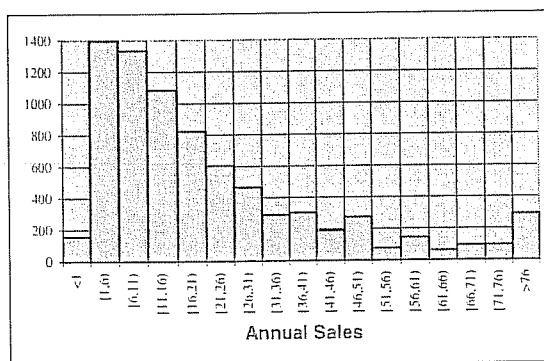
Figure 3. Annual Sales of Clients Served
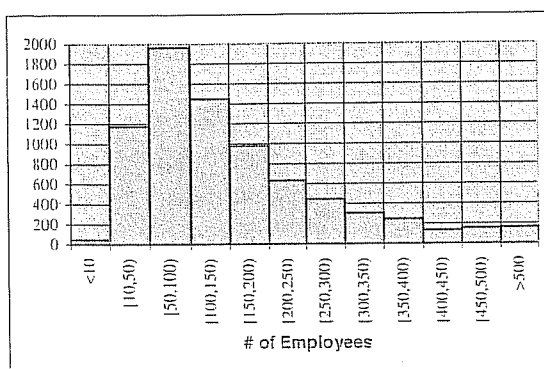
Figure 4. Number of Employees of Clients Served

Finally, Figure 5 shows the distribution of annual energy costs for the plants served in the IAC program. While distributed over a large range, the most common plant spends on the order of $200,000 per year on energy bills.

Figure 5. Annual Energy Expenditures of Clients Served

1.2.2   Assessment Profile

The database contains data from more than 7,700 assessments performed since 1981. On average, more than $53,000 is recommended per assessment while an average of almost $22,000 per assessment is implemented. This translates into an implementation rate of approximately 42%.
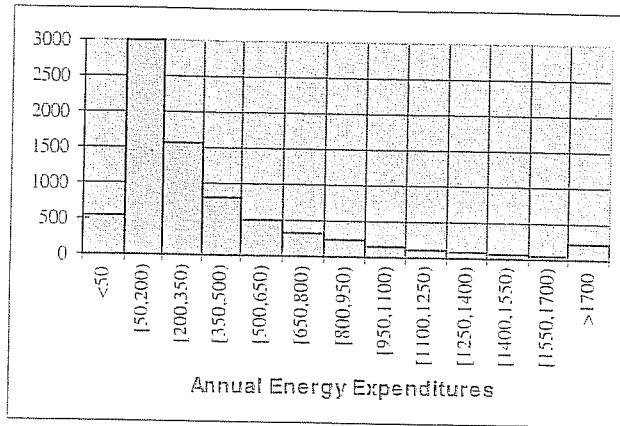
2   Expansion of Scope – The Industrial Assessment

2.1   Rationale Behind Integrated Processes

Energy auditors have traditionally considered energy conservation opportunities as being independent of other industrial opportunities, such as waste reduction/pollution prevention, and other management issues relating to productivity. Experience has indicated that energy conservation decisions are not viewed as independent by management in industry, and that many otherwise attractive modifications are not undertaken due to their relation to other production issues. The energy audit team cannot afford to be naive to the bottom line corporate mentality of the industrial managers involved. If a recommendation cannot be shown to have a secondary or even tertiary benefit to the company, the project cannot be "sold" to management.

Energy-only recommendations can have little or no impact on the productivity of a manufacturing plant. Worse, these recommendations can have a negative effect, or be considered too risky. In many industries, energy costs are a small portion of the production costs. Competition for capital is strong, and equipment purchases that increase production, or profits, will generally be favored. Internal defects have costs that are difficult to measure or estimate, such as labor for rework, moving or relocating the materials, space to warehouse raw materials or products, or even space to expand operations. An intimate knowledge of a corporation's burden, market share, and financial stability is necessary in order for the assessment team to gain the confidence of management; failure to do so can be disastrous. Excessive movement, redundant inspections, scheduling issues, and floor layout are critical issues, and ones that are sometimes impossible to evaluate during a short visit to a plant.

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2.2 Protocols for "Industrial Triage"

A concept borrowed from the medical profession, triage is a system of priorities designed to maximize success, when confronted with limited time and resources. The trick is to have as much in your toolbox as possible before, and especially during the on-site visit. The first step in an industrial triage procedure is data gathering, both from the client and from available resources, such as the IAC database, which contains the results of thousands of industrial assessments. There is no shortcut to getting the information you need (utility bills, sales figures, labor costs) from the plant personnel—it takes questioning, cajoling, and badgering. Once as much information as possible is gathered, potential draft recommendations are worked out in advance, both to predict their potential, and to determine what information will need to be gathered on site. In order to focus recommendations on company priorities or areas of interest, two separate categories are examined which relate directly to productivity:

- Increasing Pieces per Person per Hour
- Decreasing Cost per Piece

These categories are overlapping and somewhat arbitrary. They are only used as a guideline to identify the area of concern to the factory. The assessment team should also be prepared to gather data for numbers such as labor costs, cost of inventory, and overhead. However, many times the auditor will be unsuccessful in getting these figures from the client, who will often be unwilling or unable to provide such information. If data is unavailable, default values should be used, but it should be clear to the client that the values to be used in an audit report are estimates. With better numbers, a stronger case can be made to support the recommendations.

2.3 E2–P2 Connection

Pollution prevention planning has been a largely successful approach to environmental protection because it relies on the premise that increased material use efficiency is good for both the environment and for business. The planning process combines basic principles of continuous improvement and good environmental data collection and produces results that have meaning to all stakeholders: industry, government, environmentalists and the general public. Similarly, using a planning approach that would include collection of data on energy utilization, identification of cost-effective energy conservation opportunities, and implementation of energy conservation measures could produce significant environmental improvements that could be quantified and "counted" toward reductions needed to achieve air quality goals. This approach could also be used for voluntary reductions toward climate change goals and using prevention in lieu of or in addition to permit strategies to achieve point source reductions.

2.4 ISO9000/14000

A number of manufacturing facilities are developing production methods to become ISO 9000 and ISO 14000 certified. Suppliers to the automotive industry like aluminum die cast facilities are required to become QS 9000 certified so as not to lose clients. ISO or QS 9000 companies are certifying that a final product was produced by following a set of operating procedures while ISO 14000 certified companies are saying that a facility's operations follow strict environmental procedures. By expanding the scope of the IAC program to include environmental considerations and productivity improvement issues, IACs can now lend a hand

to facilities and discover ways that companies can improve operations beyond energy efficiency which can lead to gaining the ISO 9000 or ISO 14000 certification that some industries need to remain competitive.

3   Benefits and Problems

3.1   Client Attention

The scope of the IAC program has always been to perform a one day site visit, send a finished report to the client within 60 days, and follow up with an implementation call six to nine months after the report is delivered. This scope has since expanded to provide a select number of clients with multi-day assessments. An assessment team can decide to spend two or even three days in a complex or large facility, which normally would limit the understanding of the facility by the assessment team. Another way a multi-day assessment could be spent is by delivering a draft report to the client. The initial implementation call would result in the IAC setting up a time to meet with the client to discuss the report. From this meeting, misunderstandings could be clarified, implementation costs verified, and new questions could arise which the assessment team would then find answers for. A final way a multi-day assessment could be used is by revisiting a client previously audited whose implementation numbers were not very high. A meeting could be set up where the IAC and the client sit down and discuss why certain recommendations were not implemented and a re-assessment of the facility is performed. As a result of this meeting, the IAC could then gather new data and recalculate savings estimates to try to increase the number of implemented recommendations.

This greater attention the client is now receiving is mainly focused at improving implementation data. If implementation data is low, the money the federal government spends on the program appears to be going to waste. Past experience has shown that activities like delivering a draft report and spending more than one day in a facility has greatly improved the rate at which recommendations become implemented. This procedure also demonstrates a commitment to the client by the IAC to ensure that the best possible service is delivered.

3.2   Training and Qualifications

Interactions between engineering schools and local manufacturing are important for all of the parties involved. Historically, technological needs of the industrial sector were the primary source of ideas for the engineers at schools. Professors normally had significant industrial experience before joining the faculty, which insured a close connection between practical and academic interests. Over time the practical experience of engineering faculty has been greatly reduced. Outreach programs like those operated at engineering extension centers provide faculty with exposure to a variety of issues of great practical importance. Several faculty have developed ideas for research from their studies of manufacturing processes including projects like two-speed destratification fans, oscillating fluidized beds and computer controlled volumetric measurement.

It is also important to recognize that the sources of technical information for the manufacturer are predominantly vendor related and are therefore biased. Technical support from a university program is often not only of the highest technical quality, but is unbiased and therefore of tremendous use.

As the EADC program evolved into the IAC program, faculty needed to become

knowledgeable about such things as waste minimization, pollution prevention, and productivity improvement strategies. Instead of being "thrown to the wolves", directors at IACs participated in training sessions for both waste minimization/pollution prevention and productivity improvement. Such training programs are essential for the overall growth of programs like the Industrial Assessment Center program.

4 Expansion of Program Benefits

4.1 Use of Database

The IAC Program database, containing efforts from IACs for over seventeen years, is a unique resource and one that is becoming widely used. The database has been available for download over the Internet since January of 1993. It can be found on a World Wide Web site at Rutgers University (http://oipea-www.rutgers.edu) in both a downloadable version and an interactive version. Users can download the data files and can access the data from their own computers using a host of database software applications like FoxPro and Microsoft Access. Recently, an interactive front-end has been developed for the web site where users can run some common queries without having to download large data files. This becomes extremely useful when a quick answer is required to a database question.

4.2 Online Manuals

Aside from the databases, other documents and publications can be found on the web site for downloading. Three training manuals are available to help manufacturing facilities assess their operations. They are:

- *Industrial Assessment Manual:* This extensive manual was developed to be used in the training of engineering professionals who will be performing industrial assessments of manufacturing operations. It encompasses all aspects of energy conservation, waste minimization and pollution prevention.

- *Small Manufacturers Self-Assessment Workbook:* This user-friendly workbook was assembled for small manufacturers containing all of the information necessary to perform a self-assessment of their operations. It focuses on several of the most common recommendations made by auditors and provides means for estimating simple paybacks.

- *Industrial Productivity Training Manual:* During FY96, IAC Directors were trained in productivity management. The workshop was presented at the FY96 Annual IAC Director's Meeting and as a result of the workshop, the Industrial Productivity Training Manual was made available. It provides ways companies can increase pieces produced per hour and ways companies can decrease cost per piece produced.

4.3 Case History Development

Since the inception of the IAC program, all matters concerning an assessment were kept confidential to avoid leaking any proprietary information to the public and direct competitors. Recently, the IAC program has undergone a change in perspective. Companies are allowing

the use of their names to be recognized as a "Happy Customer" served by an IAC. This way, the names of these companies can be used as real case histories of savings achieved by having an industrial assessment performed. Allowing the use of a company's name is good publicity for all parties involved.

4.4 Networking for Communication of Government Resources

In response to the needs of industry, OIT created the Office of Technology Access of which the IAC program is a part. Other programs included in "Tech Access" are the Motor Challenge, National Industrial Competitiveness through Energy, Environment, and Economics (NICE³), Inventions & Innovations, the Steam Partnership, and the Compressed Air Challenge. Benefits to industry include cost savings, improved productivity, enhanced environmental quality, and recognition. The Office of Technology Access programs collectively aim to assist industry in adopting near-term and emerging energy-efficient technologies by identifying applicable programs, resources, and technologies suited to their needs.

4.5 Networking Professionals as Former Students

In addition to technology transfer, one of the major goals of the university based technical assistance programs like the IAC program is to train students in practical aspects of engineering for manufacturing. The desirability of presenting practical engineering education to undergraduate students is currently receiving great attention nationwide. The IAC program, for example, provides "hands-on" engineering training for the students who participate as well as 1-on-1 interactions with faculty. At state universities the size of classes makes individual work with students a constant challenge. These students benefit directly from exposure to the practical applications of technologies discussed in class. Students who have participated in only one assessment have commented later that even that one visit was an important part of their preparation for the "real world". But the impact on these students goes beyond simple exposure to practical applications. Students gain first hand experiences in project management and probably of greatest importance: technical report writing. There is also a large amount of close interaction between students and the faculty leaders.

One of the best ways to promote the IAC program is by getting these former students of the program involved with IAC-related activities. Most of these students have jobs in the energy management field as a result of working at an IAC and are good contacts to call on to support government funding of such a program. The alumni are made aware of current events in the IAC program through the use of an alumni newsletter and in most instances are more than happy to be called on to speak of their own personal success stories resulting from experiences obtained in working with the IAC program.

5 Future Benefits

5.1 Benchmarking

There is a great interest among energy managers at many industrial companies to be able to estimate potential energy and cost savings in their facilities. As an increasing number of industrial companies embark upon energy efficiency programs, tools such as benchmarks, can become useful to determine the impact of an energy-saving measure. Such energy estimates are readily available for lights and motors, but estimates for more complicated systems are less

accessible. There are a number of ways to calculate a quick estimate for, say, a steam system compressed air system opportunity, which are not easily determined. There are databases containing information for such fixes available as well as documented case histories. From these, analyses can be performed which could lead to a "rule of thumb" for an energy-saving opportunity. However, other methods, like metering, could provide more accurate conclusions when estimating the impact of implementing an energy conservation technique. This would involve installing a data logger and other measurement equipment on a process system in the plant. Both a before and after picture would be necessary to truly measure the response of an energy efficiency improvement. At regular intervals, data would need to be collected from which conclusions could be drawn and an overall estimate of how such a fix would affect similar systems in similar facilities could be calculated.

5.2 Combined Heat & Power (CHP)/Deregulation

In the United States, the selling and distribution of electrical power will soon become a competitive industry due to the deregulation of electric utilities. Cogeneration, or combined heat & power, will become more popular. There will be companies out there who will come and install such a unit in a manufacturing environment and also own, operate, and maintain the unit. The facility will then pay for this service as one way to obtain competitive electrical rates and at the same time, receive heat for use in the process or for space heating purposes. The expertise of the IACs will be able to help determine what is best for facilities in this new age of deregulation.

5.3 System Optimization

Finally, IACs are well on the way to becoming experts in energy efficiency, waste minimization, pollution prevention, and productivity enhancements. Overall process and system optimization will become the focus of many IAC assessments. The E2-P2 connection will begin to play a bigger role as the new millenium is upon us. Greenhouse gas emissions must be reduced, yet company growth is still important to the economy. If all things, energy, waste, and productivity, are considered, all economic and environmental goals can be reached and the IAC program will be there leading the way.

6 Acknowledgements

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Norwegian Industry's Network for Energy Conservation

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Summary

A central goal of Norwegian energy policy is to promote socially and economically acceptable exploitation of available energy sources. The industry accounts for 40% of the total energy consumption in Norway, of which electricity from hydro-power supplies 77%, oil products 13%, and coal, coke and wood the remaining 10%. Major initiatives to stimulate energy efficiency include prototype and demonstration programs for new energy-efficient technologies, energy analysis support, investment grants and information and training programs.

The Norwegian Industrial Energy Efficiency Network (IEEN) was established in 1989 and is the major program for implementing national energy efficiency policies and measures in industry. The main objectives are improved energy efficiency in SMEs and improved decision capabilities of individual companies in matters regarding energy and environment. More than 500 companies from 13 different industrial sectors, representing 70% of industrial energy use, are currently organised in the IEEN. The network acts as an information link between the industry, suppliers of equipment and services and the authorities, and provides in fact a tool-box for various national energy efficiency measures. Such tools are grant programs, statistics on energy use, training programmes, implementation of methodologies and technologies. Main topics include:

- Organisational, financial, methodological and behavioural support schemes, comparable energy statistics, education and training programmes
- Promotion and implementation of new technologies, by prototype and demonstration, technology and sector studies, and stimulation of energy efficiency investments
- Increased management attention to energy efficiency
- Reduction of existing information barriers between industry, suppliers of equipment and services and the authorities.

The IEEN network has been successful in reducing such barriers, as well as in encouraging private enterprises to invest in profitable energy efficiency measures.

1   Introduction

In Norway, as in most OECD countries, electricity and petroleum products are the pre-dominant energy carriers. Electricity, however, accounts for a relatively larger share of the total energy consumption, of almost 50% in 1995 compared with 40% for petroleum products and 10% for solid fuels including coal, coke and wood. Practically all electricity is produced by hydro power. The total energy consumption in 1996 was 214 TWh, of which the industry accounts for approximately 37% (Ref. 1). Recent development in energy use (1984-94) by

different sectors is shown in Figure 1.

Figure 1. Sectorwise energy consumption in Norwegian industry (%)

1984

1994
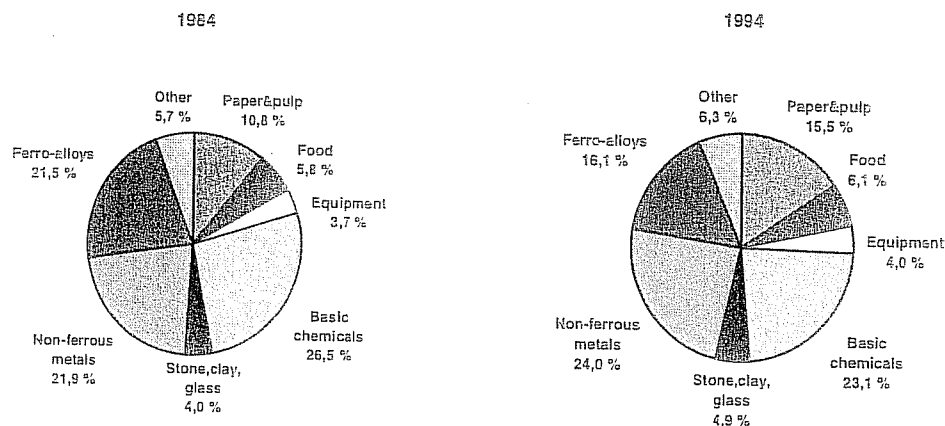
Increased energy efficiency has been an important part of Norway's energy policy since the mid 1970's. A main national objective is to ensure rational use of energy resources with a minimum of adverse environmental effects. However, public interest and government attention to specific measures has varied considerably over the past decades.

Figure 2 illustrates the current organisation of our national energy efficiency work. The Norwegian Water Resources and Energy Administration (NVE) has an overall responsibility for governmental efforts in this field. Local energy utilities are required to implement certain energy efficiency measures towards energy users in the area. These activities also include the provision of information and energy advice, and are increasingly being financed by a supplementary charge of approximately 0,5 % on local electricity prices. To implement these activities, Regional Energy Efficiency Centres are established. Practical implementation of various measures has to a large extent been delegated to Operating agents, i.e. institutions and organisations outside the central government. Institute for Energy Technology (IFE) is thus responsible for the industrial sector.
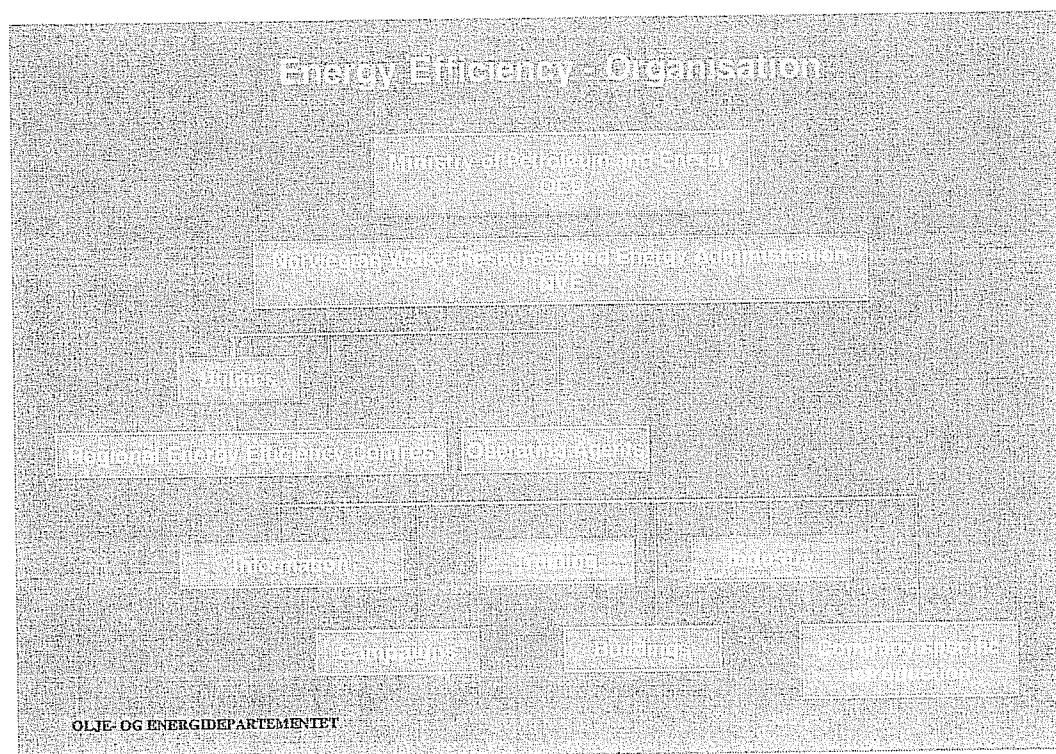
Figure 2. Organisation of national energy efficiency works in Norway

2　The Industrial Energy Efficiency Network

2.1　Background

Historically, low energy prices did not stimulate industry to invest in energy-efficient technology, resulting in a fairly large potential for improvements as energy prices started to rise in the 1970's. The idea behind the Norwegian Industrial Energy Efficiency Network (IEEN) originated in Canada, i.e. the Canadian Industry's Programme for Energy Conservation (CIPEC). Their concept was adapted and further developed to the needs of the Norwegian industry. Initially, three sectors joined the IEEN: the pulp and paper, the dairy and the manufacturing industries. Since this limited start, the IEEN has grown to cover 13 industrial sectors at present.

2.2　Description

Norwegian authorities have relied on and supported the IEEN to achieve better co-ordination of energy efficiency measures and activities in the industrial sector since the late 1980's. Currently the IEEN includes more than 500 Norwegian companies representing 13 different industrial sectors, as shown in Figure 3. The IEEN activities, with a total budget of 1.5 mill US$ in 1997, are financed through the Norwegian Water Resources and Energy Administration (NVE). It is organised as a project under the operating agent for industrial energy efficiency activities and is governed by an executive committee of industrial representatives subject to overall guidelines from NVE, as illustrated in Figure 4. As operating agent for industry, Institute for Energy Technology (IFE) is responsible for the secretariat and daily administration of IEEN activities.
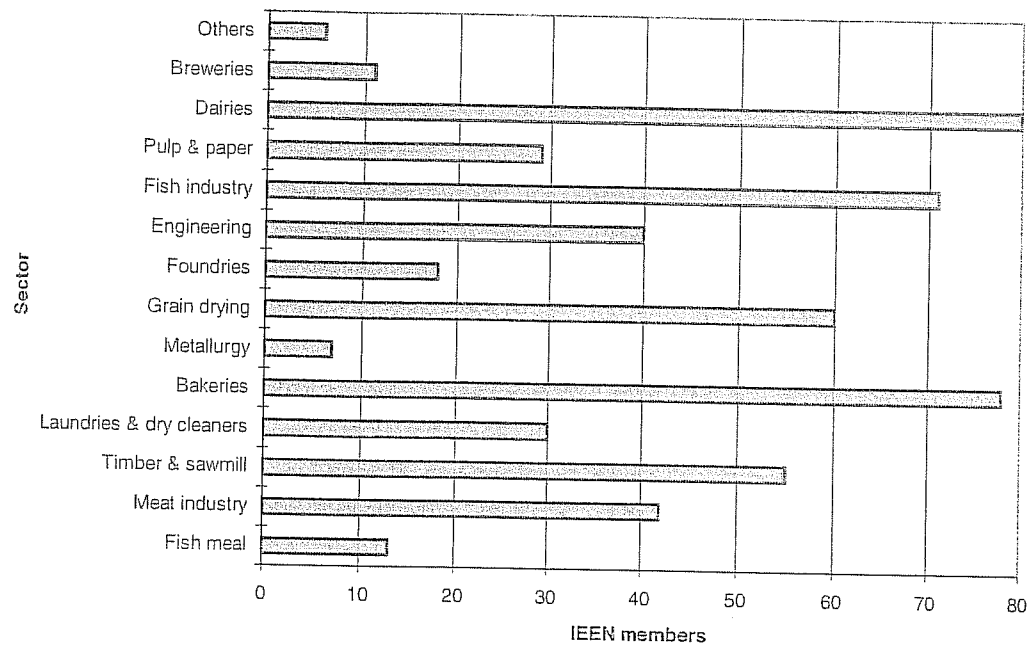
Figure 3. The Norwegian Industrial Energy Efficiency Network – participating industries
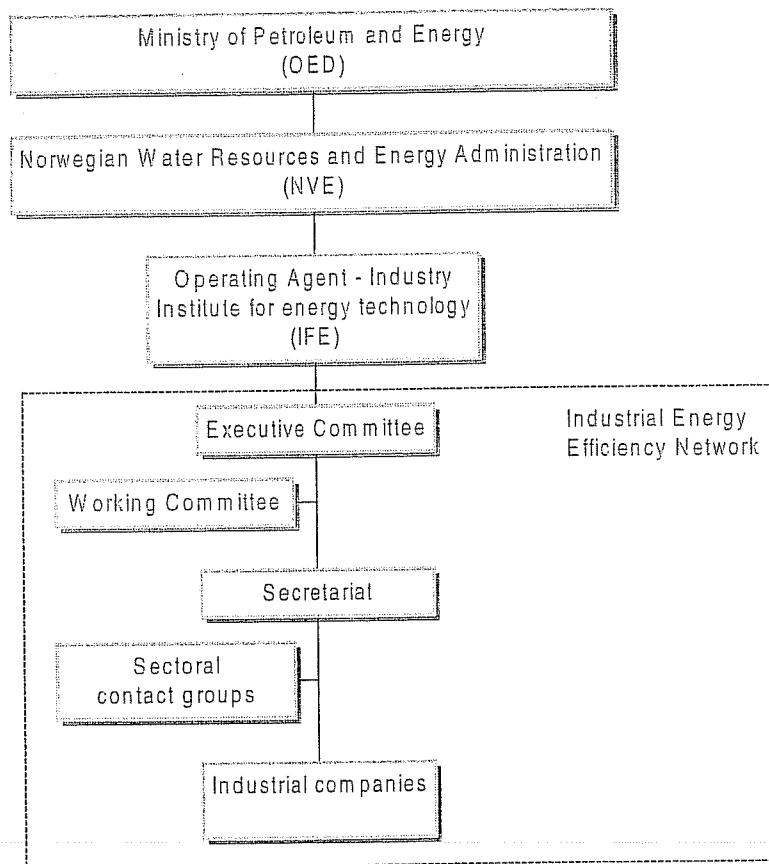
Figure 4. Organisation of IEEN

General agreements are made with industrial sectors through their trade associations, and individual companies may under such a general agreement voluntarily join the IEEN. At present the only requirement for membership is the provision of an annual statement of energy consumption and production volume.

The executive committee of industrial representatives is authorised to establish strategy and a programme of work within the overall external budgetary framework. The industry also has a high degree of influence through the sectorial contact groups, which develop priority lists and action plans for annual activities in their sector. In practice this implies that each sector may adapt IEEN core activities, tailor-made to specific needs.

In each member company there is a contact person in charge of information transfer with the secretariat. In addition the IEEN acts as a communication link between the industry, energy consultants, suppliers of products and services and the authorities, with the aim of reducing existing information barriers between them.

A main objective of the IEEN is to improve industrial companies' in-house ability to make optimal decisions regarding energy and the environment. Larger industrial companies usually have sufficient up-to-date in-house knowledge of relevant technological developments and necessary resources to place priority on these issues in contrast to SME's. The current IEEN strategy is based on elements described in the following.

2.2.1 Information and Motivation

The main information and motivation activities are based on publications and tailor-made seminars. Two regular publications are issued to the members: the quarterly newsletter and the annual report (ref. 3). The newsletter contains energy efficiency information of both general and sector specific nature and functions as a news bulletin. Other important information activities include sectorwise bi-annual tailor-made seminars and targeted information such as description of EU-projects and IEA CADDET material.

2.2.2 Energy Management and Analysis Support

A new and important service to IEEN members is energy management and analysis support. Energy management has so far been a common tool in energy intensive industries, only, not applied among the large majority of Norwegian SMEs. As member of IEEN, a company, plant or site are offered experienced energy consultant assistance in designing and implementing an energy management system, more or less free of charge. To ensure efficient follow-up from the company, it is required that relevant processes and systems are well specified, and that results are reported. More detailed technical analyses are available, and financial support (of 50%, limited to US$ 12,000) may be provided for member companies. This normally includes monitoring of individual and aggregate loads and different manufacturing equipment performance data. The methodology and tools are developed gradually over periods of several years and adapted to the specific environment and other conditions in the different sectors.

2.2.3 Comparable Statistics and Benchmarking on Specific Energy Consumption

A key activity of IEEN is the comparable statistics acquisition and benchmarking of specific energy consumption in different sectors, based on annual company reports of energy consumption and production data. These data are quality controlled and processed to obtain average sectorial benchmarks of specific energy consumption. In general, if there are large differences in energy consumption of different manufactured products, statistical methods, such as multi-variable regression analysis are used to obtain sector-wise specific energy consumption. The benchmark results are used actively to motivate companies to improve their energy efficiency. The IEEN annual report presents company specific energy data in an anonymous manner, as exemplified in Figure 5a and Figure 5b.
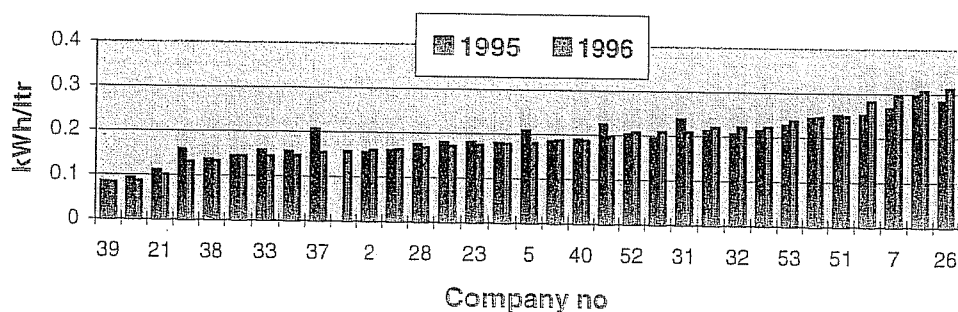

Figure 5a. Specific energy consumption (kWh/l) in the Dairy industry (drinking milk)

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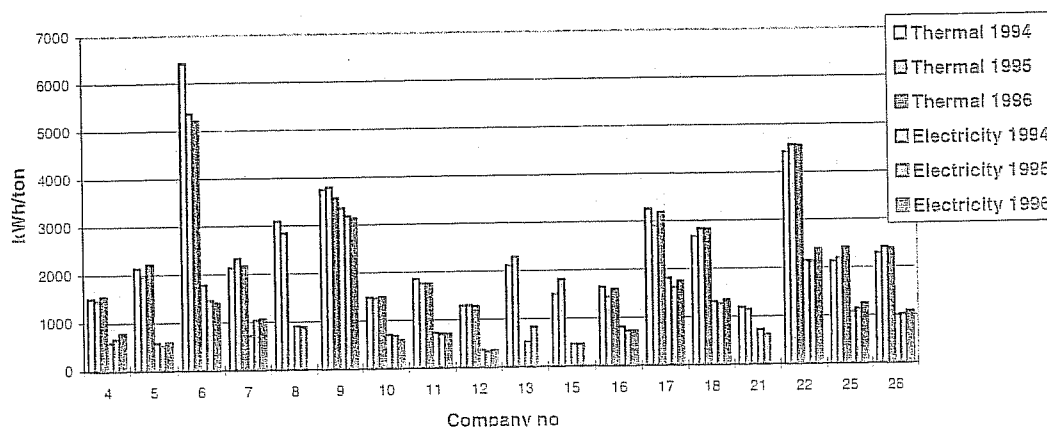
Figure 5b. Specific energy consumption (kWh/ton) in the Pulp and paper industry (paper production)

2.2.4 Prototype and Demonstration Projects

A decisive factor for industry to invest in more energy-efficient technology is to demonstrate its economic viability. The IEEN does this by identifying best practise examples of energy efficiency projects, monitoring them and producing project reports, distributed to target groups. Project presentations may be made in connection with on-site seminars. The IEEN may finance part of the investment, monitoring and project reports, limited to 50% of the total costs.

2.2.5 Sector and Technology Studies

Sector and technology studies are used as important tools to investigate energy efficiency potentials within sectors and from introduction of best available technologies in given sectors. These studies may be regarded as sectorial energy audits, and are also performed for new sectors prior to joining the IEEN.

In case of a new technology applicable to several sectors, there are normally incomplete assessments available on the energy efficiency potential of this particular technology in the different sectors, and targeted studies may then be undertaken to establish this potential. The IEEN may also finance such studies.

3 International Applications

International research and assessments indicate that in many countries lack of relevant information and up to date knowledge about relevant technological developments, still constitute major barriers to improved energy efficiency in industry. Capacity building and the Norwegian IEEN concept and know-how have proven valuable and efficient tools to increase problem awareness, competence and implementation, especially for countries in transition to market economy, as the former Soviet Union and Central and Eastern Europe.

3.1 IEEN in Poland

Based on years of experience from energy efficiency efforts in Poland, IFE introduced the concept of IEEN in 1995, as a tool to integrate energy efficiency in the Restructuring Program

for the Polish Agricultural Industry, established to assist the process of restructuring and privatisation of industry. Under an agreement made with the Ministry, a program was carried out to establish and develop a Polish IEEN (SEGE) for the agricultural industry with the aim to contribute to cost savings by improved energy efficiency.

Agreements have so far been signed with 4 sectors (sugar, grain and milling, dairies and food freezing) to participate in a 3-year test period (1997-99). Approximately 150 individual companies have signed voluntary agreements for memberships. An Executive Board representing the industrial sectors has been established to develop the strategy for the network, together with sectorial contact groups and a secretariat. Relevant governmental bodies are also represented on the Board as observers. Each member company has appointed a contact person responsible for collecting data, communication with the secretariat, dissemination of information, etc.

Main activities planned for the test period include acquisition of statistics on energy consumption and production volumes and benchmarking of specific energy consumption, training courses, demonstration using reference plants, information and motivation initiatives (seminars, newsletters, dissemination of results etc.).

A convincing incentive for company management to invest in energy efficiency measures is to demonstrate their economic profitability. Reference plants will be used to promote good examples, which will be documented and disseminated. On-the-job training using the reference plants will be organised.

3.2 Croatia

The IEEN concept was introduced in Croatia in 1997. The network (MIEE) is one of ten national energy programs established by the Government of Croatia to contribute to the restructuring of the energy sector. An Executive Board with representatives from governmental organisations and relevant technical institutions are responsible for strategy and co-ordination with national policy. The Government has appointed the Croatian Energy Institute to further develop and implement strategies for the network. A program of work for a 2-year test period (1998-99) has been developed using the Norwegian concept. So far the tourist industry, pulp and paper industry and health sectors are participating.

4 Results and Success Factors

Experience from more than 5 years of operation of the IEEN in Norway clearly indicates that the program has been a success. The IEEN sectors cover more than 60% of all stationary energy consumption in Norway. The majority of sectors participating have reduced their specific energy consumption by approximately 1,4% annually, which is partly due to increased awareness and energy management. The IEEN acts as a communication link between the industry, consultants, suppliers and the authorities. Governmental incentive programs are channelled through the IEEN, but as there are no national targets for improved energy efficiency in Norway, the IEEN has not been measured against such performance criteria. Since the IEEN basically is an information tool, it has limited impact on the investment strategies of individual companies.

Recently a survey has been accomplished among the EIIN members. A professional market institute (MMI) interviewed 40% of the members. The results can be summarised as follows:

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- 90% agree that the EIIN is important for the promotion of energy efficiency in industry.
- 85% agree that it is important for them to take part in the network.
- 79% are interested and participate in the EIIN seminars.
- 80% agree that the EIIN annual report brings new facts and knowledge.
- 86% is satisfied with the information about their own trade.
- 54% are not interested in reading about other trades.
- 60% have invested in energy efficiency the last two years.

In establishing such networks, however, our experience indicates that certain basic principles and conditions are important and should be considered. Obviously, government commitment, as well as political support and financial resources from relevant authorities are important success factors. Network objectives should be clearly defined, based on national energy/environmental policy, and there should be obvious benefits for both industry and authorities. Industry commitment is essential, and it may be advantageous to develop the network gradually, from a limited number of motivated sectors through agreements with their trade associations. In our experience executive committees/boards have been efficient in developing network strategies within given political and financial framework, whereas industrial influence is best secured through sectorial contact groups.

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Russian Industry: Paving Road to Rationality

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Russia

Russians should be rational. "Russian" and "rational" sound close. But at least in energy efficiency there is a long way to go before Russian economy becomes rational. Industry can go faster if this way to rationality is paved.

Exhausting cheap oil, gas, and coal resources for decades Russia simultaneously has been accumulating the largest energy conservation potential in the world. Only limited number of companies own or control energy resources and large energy generation facilities. But every enterprise possesses energy efficiency resources. Improving fuel efficiency and creating conditions for the transfer of Russia's economy to energy-saving path was declared one of the top priorities in the Energy Strategy of the Russian Federation. Two years after its adoption improving energy efficiency is not yet a usual business in Russia. Sharing industry experience should go along with the support of technologies transfer. Of course, Russian economic situation is far from being a paradise yet. Nevertheless, continuation of market reforms will provide a solid basis for mutually beneficial projects and contracts.

1 Russian Energy Picture

Both primary energy production and consumption in 1997 were 27% below the 1990 level and even below the 1980 level (see Figure 1). Those two major energy indicators did not decline as fast as GDP.
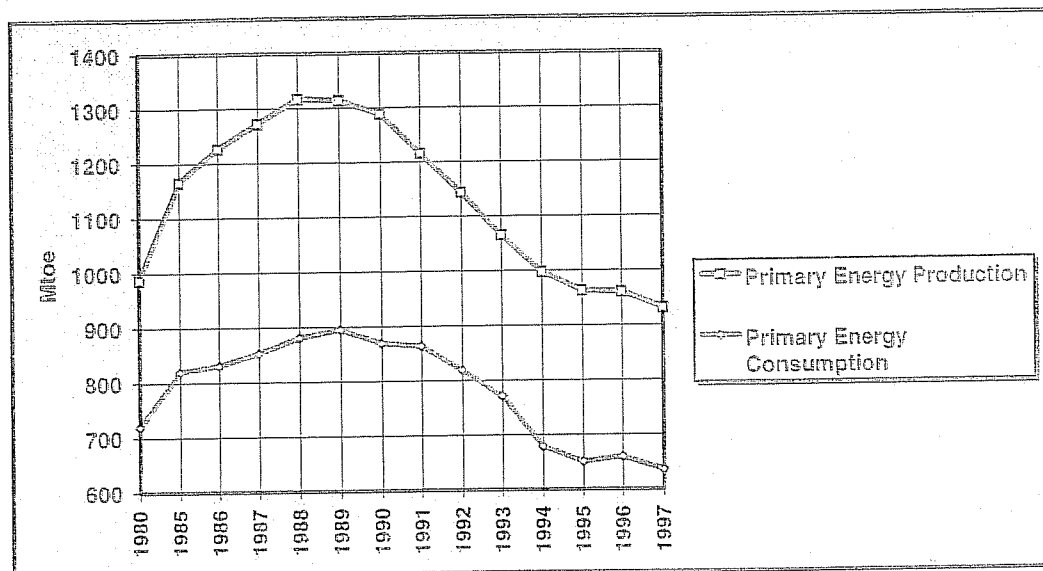
Figure 1. Primary energy production and consumption

Source: Russian Energy Picture. CENEf.

Energy production and consumption decline was accompanied by substantial structural changes in the Russian energy balance. The role of natural gas was continuously growing at the expense of liquid and solid fuels. Presently, natural gas contributes about 50 percent to the total primary energy consumption.

In 1993, Russia's primary energy consumption per unit of gross domestic product (GDP) estimated by the Russian Committee for Statistics (Roscomstat) under the International Comparisons Program was 3.3 times higher than in the U.S., and nearly 6 times ahead of Japan (Figure 2). Over 1990-1997, GDP energy intensity of already inefficient economy leaped by additional 25% (see Figure 3).
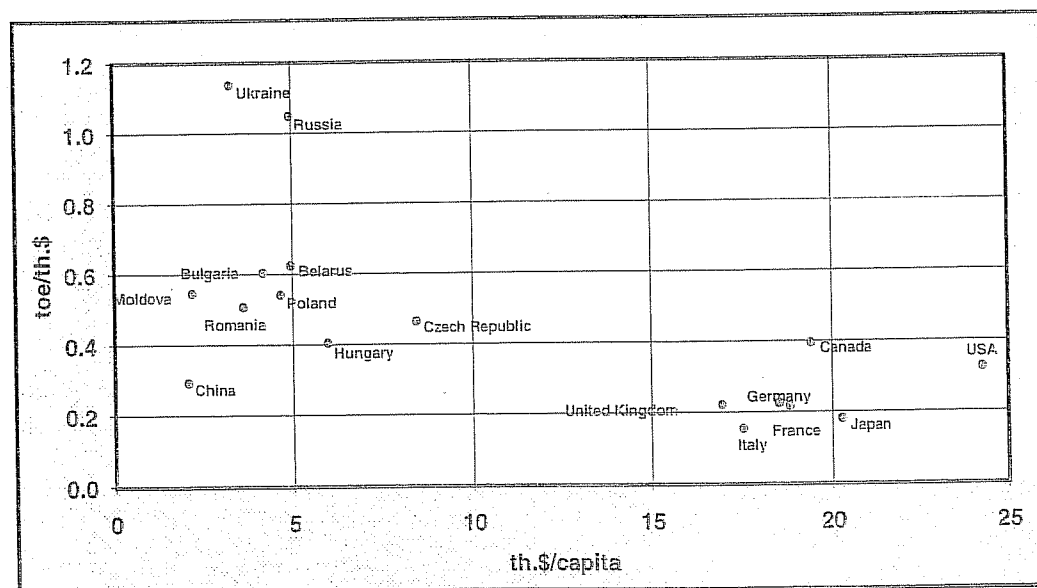
Figure 2. Primary energy consumption per unit of GDP versus level of economic development

Source: Russian Energy Picture. CENEf.

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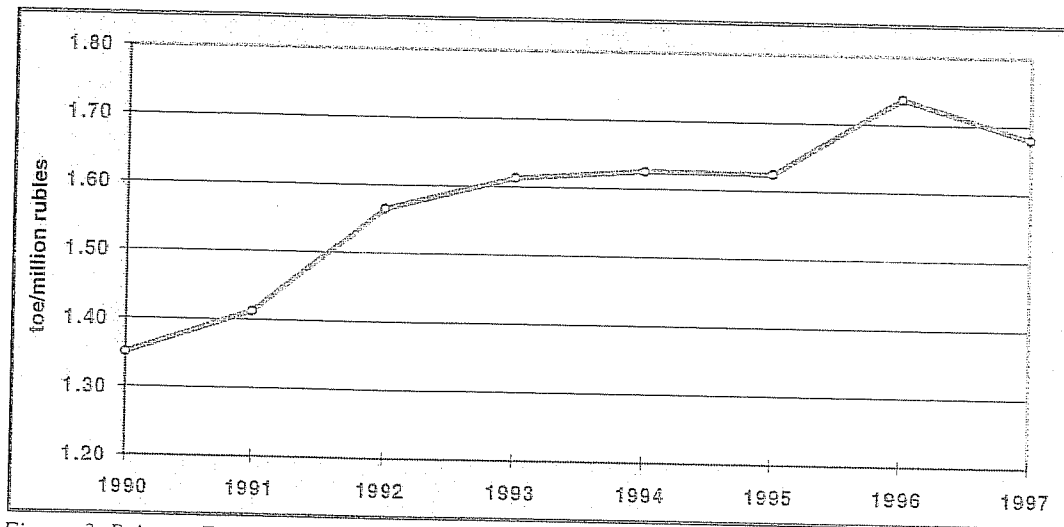
Figure 3. Primary Energy Consumption per Unit of GDP

Source: Russian Energy Picture. CENEf.

Russia's energy efficiency gap matters, because it:

⇒ impacts the competitiveness of the Russian economy by reducing economic productivity,
⇒ consumes badly needed capital if 'doing nothing' policy is taken, and
⇒ uses energy resources that could otherwise be exported;
⇒ tremendous financial resources are re-distributed in favor of energy utilities.

2   Energy Consumption in Industry

Energy consumption in industry in 1990-1997 declined by only 26% on the background of industrial production declining by 52%. Such a situation naturally pushed industrial energy intensity up by 55%. (See Figure 4).
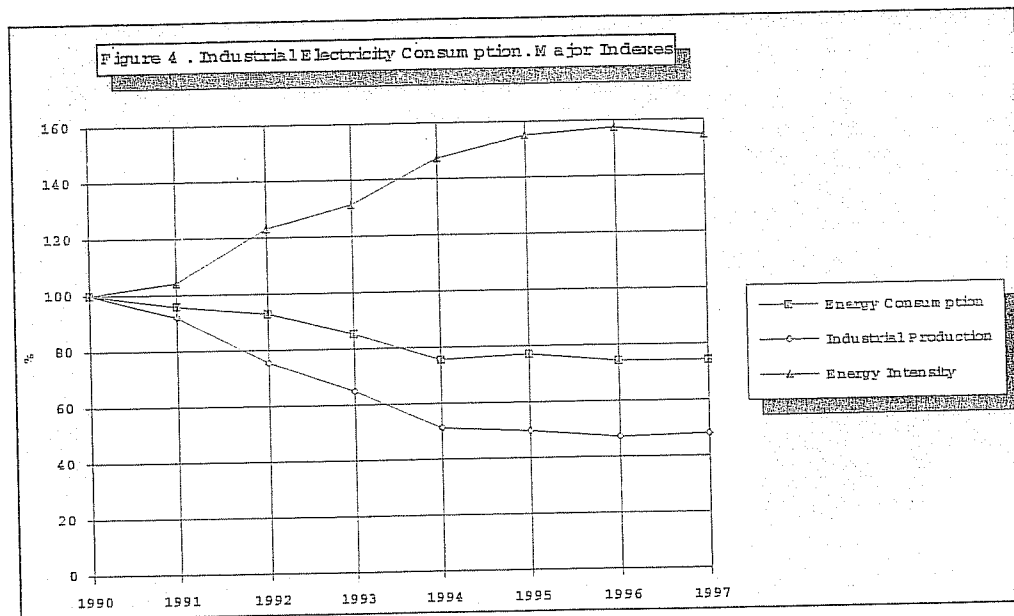
Figure 4. Industrial Electricity Consumption. Major Indexes

Source: Russian Energy Picture. CENEf.

As a result Russian industry ranked even higher in the list of the least efficient industries around the world. The fuel mix for the industrial sector in 90's was relatively stable. (See Figure 5). District heat dominates the energy balance of Russian industry, followed by natural gas, electricity, coal, and petroleum products.
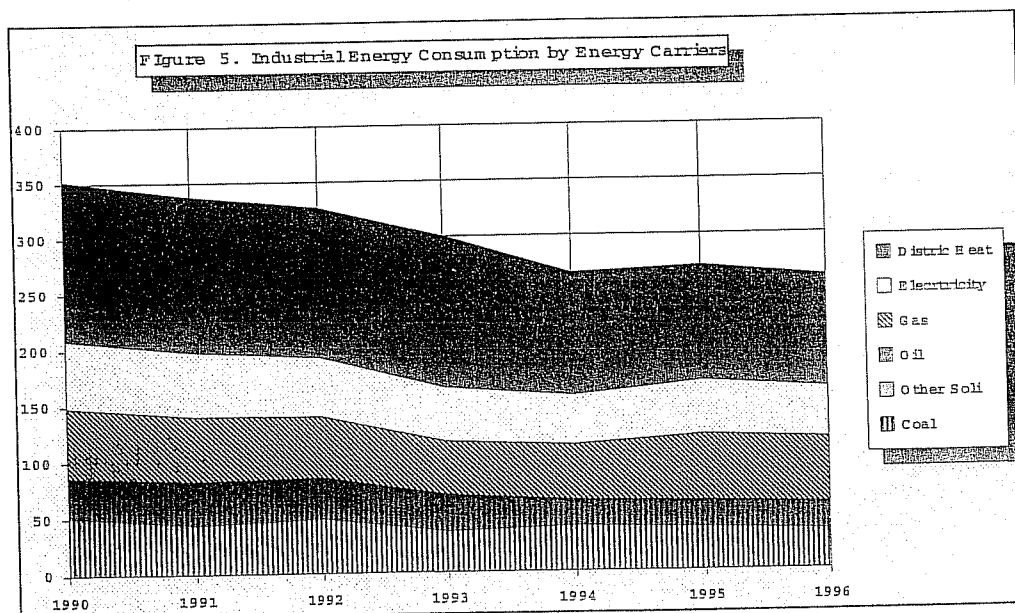
Figure 5. Industrial Energy Consumption by Energy Carrier

Source: Russian Energy Picture. CENEf.

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Some structural and other factors typical of economies in transition produced negative effect on industrial energy efficiency:

- shifts from energy intensive industrial structure towards very energy intensive structure due to competitive advantage of Russian energy and raw materials processing industries in international markets and loss of competitive advantage of less energy intensive industries both in the national and international markets;
- reduction of production capacity load and corresponding growth of non-production related energy processes share, e.g. lighting, heating, ventilation, and air-conditioning;
- deterioration of industrial technological base and equipment due to lack of investments;
- lack of experience in running industrial energy systems in a market environment;
- failure of top management to realize that efficiency improvements is the most promising production costs reduction strategy;
- non-payment problem;
- lack of market-induced costs reduction discipline;
- lack of metering and controls;
- fuel and energy supply monopoly;
- entitlement mentality—state will provide cheap energy.

Structure of industrial production shifted in the favor of heavy industries, but energy intensity in each branch of the industry grew up (see Figure 6). This growth was mainly driven by the reduction of capacity loads and growing share of non-production related energy processes. The correlation is clear: the lower is capacity load, the higher is intensity growth and vise versa.
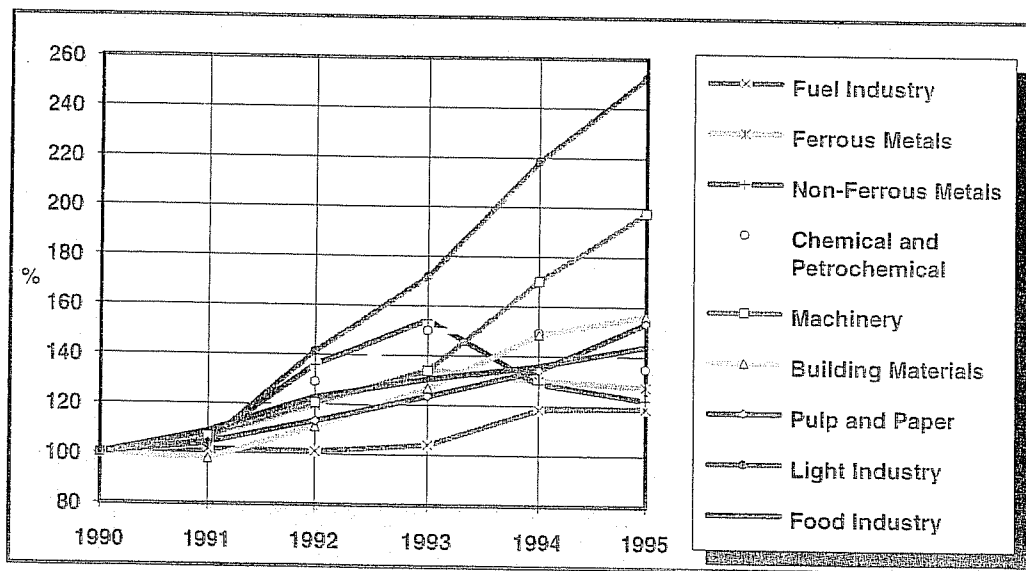
Figure 6. Industrial Energy Intensity
Source: Russian Energy Picture. CENEf.

Within each industry production mix changed also in the favor of more energy intensive articles. As to product by product specific energy consumption, it has shown no clear evidence of improvement in 1990-1997, except for cement production. At the same time, specific energy consumption grew up substantially in steel rolling and oil refinery.

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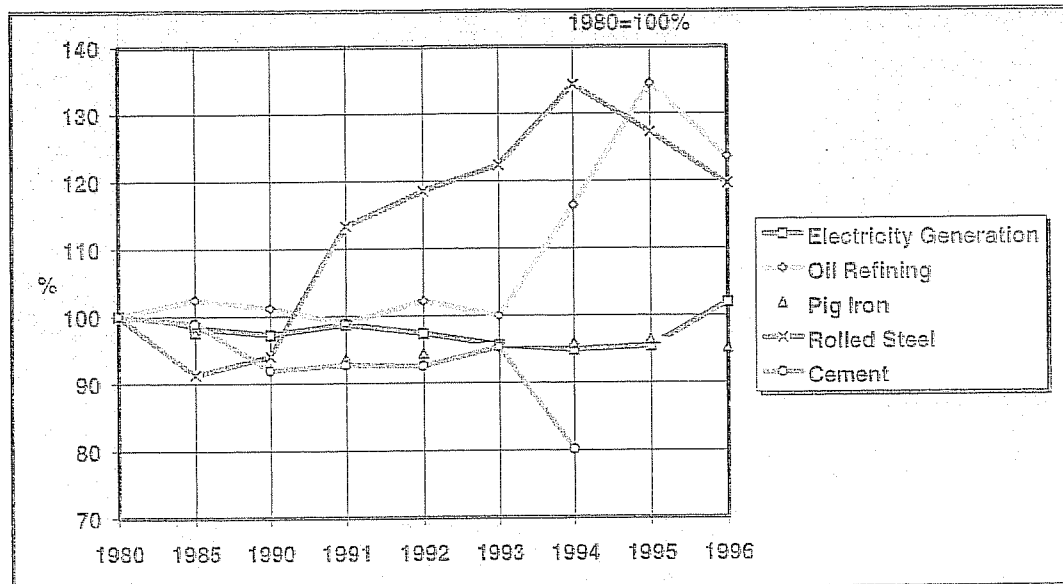
Figure 7. Specific Energy Consumption
Source: Russian Energy Picture. CENEf.
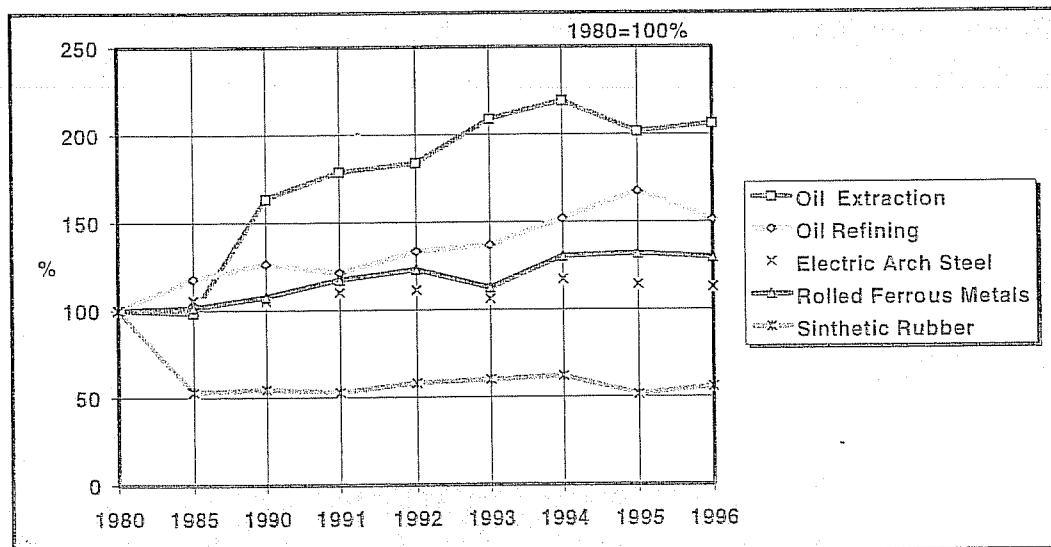
Figure 8. Specific Electricity Consumption
Source: Russian Energy Picture. CENEf.

Specific electricity consumption declined only for synthetic rubber, and grew up for all other products depicted in Figure 8.

3   Energy Prices and Energy Costs

In a market environment, market forces, price signals in the first place, are to determine proportions and efficiency of production factors utilization. But there are a number of barriers that keep price signals from impacting energy efficiency improvements.

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In Russia, these barriers are numerous. As a result, industrial energy intensity was increasing against the background of rapid growth of energy prices (see Figure 9).
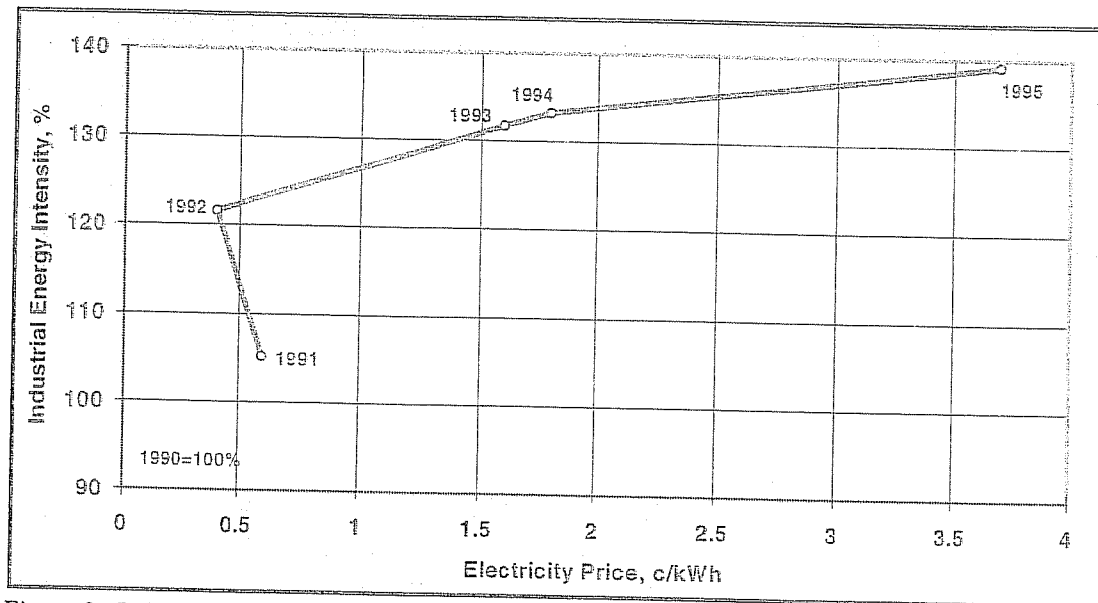
Figure 9. Industrial Energy Intensity versus Electricity Price
Source: Russian Energy Picture. CENEf.

When put in the equivalent US dollar terms, energy prices keep very much to the world prices, and in some cases they are even well ahead (see Figure 10).
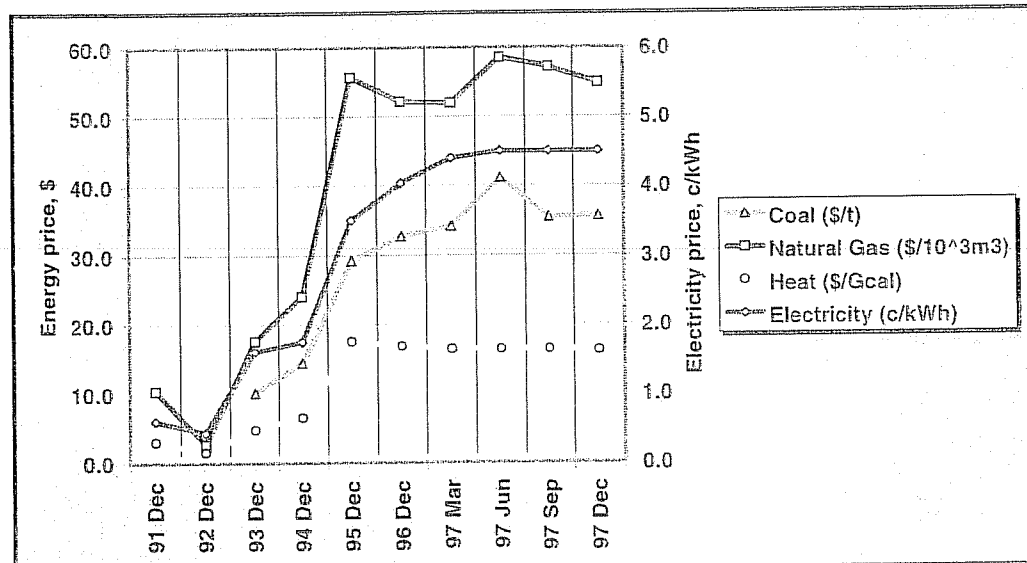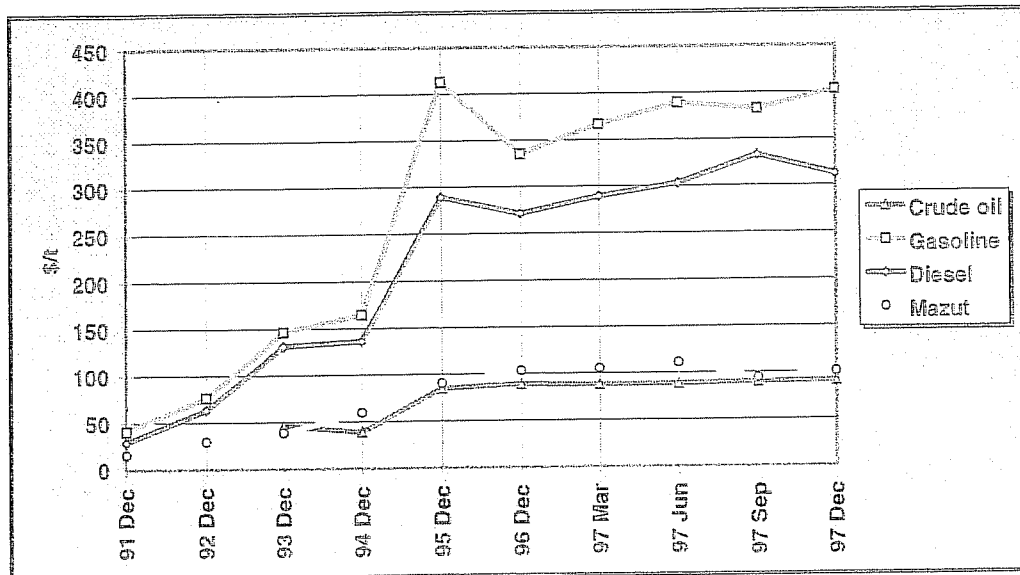
Figure 10. Average Industry Energy Prices
Source: Russian Energy Picture. CENEf.

Higher energy prices have triggered non-payment of energy bills rather than consumption and end-use efficiency. Energy prices in Russia are at, near and even exceed the levels of developed countries. Russian energy prices are no longer directly subsidized except for residential heat and hot water.

Subsidies may be of two forms: cross subsidies from industrial to residential consumers (electricity tariffs) and subsidies from future generations of energy consumers because current energy prices do not include all operating and maintenance costs. Undistorted (higher) energy prices cannot play their role if energy bills are not being paid (as is the case in Russia).

Action to be taken, if price hikes are to have impact. The Russian Government's apparent aggressive economic restructuring and energy price reform, combined with steps to resolve the non-payment problem (e.g. negotiation of debt reduction, elimination of energy subsidies),

should contribute to a more rational economic system. In turn, this should introduce the appropriate price signals regarding the consequences of inefficient energy use. However, it will take time for these changes to work their way through the system and bring along large scale results.

As it is shown in Box 1, the Russian industrial sector is the most sensitive sector to price fluctuations: price elasticity is negative and relatively high. But the sped of price growth was such, that even those most flexible industrial consumers were not capable to neutralize the impact of price growth on production costs.

<table>
<tr><td colspan="3">Box 1</td></tr>
<tr><td colspan="3">Electricity Price Elasticity of Demand and Debt for One Russian Electric Utility</td></tr>
<tr><td colspan="3">Price Elasticity of Demand</td></tr>
<tr><td>Large industrial consumers</td><td>-0.117</td><td>-0.297</td></tr>
<tr><td>Residential sectors</td><td>-0.180</td><td>-0.204</td></tr>
<tr><td>Small industrial consumers</td><td>-0.040</td><td>-0.175</td></tr>
<tr><td>Commercial sector</td><td>-0.069</td><td>-0.080</td></tr>
<tr><td>Railroads</td><td>0</td><td>-0.068</td></tr>
<tr><td>Agricultural sector</td><td>-0.015</td><td>-0.271</td></tr>
<tr><td colspan="3">Price Elasticity of Debts</td></tr>
<tr><td>Industrial sector</td><td>1.2</td><td></td></tr>
<tr><td>Agricultural sector</td><td>1.7</td><td></td></tr>
</table>

Source: I. Bashmakov, S. Sorokina. Evaluation of tariff policy impacts on utility's revenues. Energy Efficiency. [1] 13, 1996. CENEf.

Due to blind government policy energy prices in Russia jumped over monopolistic price limit. The first result of such policy—sharp declining of industrial production, and the second—revenue losses by energy supply companies.

4   Industrial Efficiency Improvements: Success Stories

Energy tariffs are high. That makes energy efficiency a priority, when production costs reduction strategy is addressed. Production costs reduction is the basic means to improve the competitiveness of Russia's economy. Energy costs reduction is the basic means to reduce production costs. Bringing together knowledge and efforts of energy consumers and manufacturers of energy-efficient equipment is the basic means to reduce energy costs.

Where there is a will there is a way. Many obstacles are still there. They are to be removed and road shall be paved. Obviously, people with a strong will are needed to overcome them and go beyond limits to make Russia's industry rational.

There are clear signs that top management of Russian industrial corporations realized the importance of effective energy management in the corporation strategy on production costs reduction. Chief energy managers of many industrial enterprises were required to develop energy costs reduction programs. While this requirement is set there are not enough experience at the enterprises in developing and implementation of such programs.

There are more and more examples in Russia when due to very aggressive programs and

efficient energy management in a very short time frame energy related costs felt down by 15-20%.

4.1 Magnitogorsk Metallurgical Plant

Magnitogorsk Metallurgical Plant is gigantic industrial enterprise located at Urals. In 1996-1998 special energy consumption was reduced from 9.82 to 7.83 Gcal/t crude steel, or by 20%. That is mainly a result of Center for Energy Efficient Technologies activities. This Center was created three years ago and presently employs 170 people. It has four departments:

- metering bureau;
- control group;
- adjustment group;
- design group.

The most important starting point was the development of wide spread metering system all around this gigantic industrial facility. This is the responsibility of metering group. Presently readings from more than 700 devices are collected and analyzed daily. Based on this information, energy balances of the whole enterprise as well as for separate energy carriers and separated shops were reconstructed and norms for specific energy consumption, and limits of consumption are set for each of major production departments. One of the main task is to reduce peak loads for morning and evening maximums, introducing more flexible production regimes.

The control group is responsible for identification of losses as well as for checking the implementation of technical rules for energy consuming equipment. Adjustment group is responsible for turning equipment parameters (burners, furnaces etc.) to get highest possible efficiency for given production regime. The design group is responsible for designing implementation of proposals which leads to the reduction of energy consumption.

Among the most important measures are:

⇒ utilization of coke oven gas and blast furnace gas;
⇒ utilization of secondary heat;
⇒ decentralization of the compressed air production;
⇒ reconstruction of own power sources (three power stations with total capacity 400 MWt.

The whole four years energy efficiency improvement program (1998-2001) costs 480 million US$. The Magnitogorsk Metallurgical Plant will invest 30% of funds required, and the rest 70% are to be mobilized outside.

4.2 Moskabelmet

This is a electric cable manufacturing plant located in the center of Moscow. The share of energy costs in production costs grew from 4% in early 90's to 7% in 1997. The negative impact of high-energy prices on production costs was neutralized by permanent energy efficiency improvement activities promoted by the top management of the enterprise.

All measures were implemented for Moskabelmet own expense.

Metering again was the departure point for the whole program. It was followed by the introduction of peak demand management system. Next step was installation of steam traps, which allowed to save 20% of consumed heat. All heat supply pipes were replaced or insulated. All water supply system was reconstructed.

District heat for the utility is very expensive. Moskabelmet installed its own boiler house (3.7 million US$ worth), which generates heat for just 60% of utility price.

Based on collected statistics specific energy consumption by each shop were estimated and enforced in line with the introduction of economic incentives for complying with those norms. General director personally monitors on regulatory basis the work of that system.

4.3 Ekaterinburg Machinery Building Plant

This plant started from low cost measures. Introduction of strong control allowed to reduce water consumption by 35% and electricity consumption for lighting by 50%. Due to the reduction of internal shops temperature heat consumption felt down. Low capacity load was the reason for conservation of several shops and warehouses. That measure brought significant savings. The production from conserved shops was transferred to another ones.

Another set of measures is related to the decentralization of heat, compressed air. Small efficient local boilers replaced large one. Such action provided basis for the substantial reduction of heat losses. Decentralization of compressed air supply was accompanied by the reduction of electricity consumption by 40%.

Much more examples of active energy efficiency improvement policies can be demonstrated. But such activities are still not business as usual in Russia. Strong government promotion of energy efficiency improvements in industry is required.

5 Government's Failure to Pave the Road for Energy Efficiency Improvements in the Industrial Sector

Lack of professional communication and shortage of information limit ability of industrial energy manager to identify opportunities to launch energy efficiency improvement programs. Consolidation of forces is required not just for experience sharing, but also for transforming industrial energy consumer from the position of utility slave to the position of equal partner. Another important task is to enforce the position of industrial energy manager in hierarchy of top management in correspondence with the role of energy in the production process and its share in production costs.

Both directions require unification of industrial managers, require training, participation in the development of energy and pricing policy and regulations.

Russian government up to date did nothing to push such processes. No incentives are provided to industrial plants to develop energy efficiency improvement programs, like for example in the Check Republic, where government provide subsidies for conducting energy audits. CENEf proposed similar scheme in the Draft law on improving energy efficiency in Kostroma oblast.

There is a special section on *Energy Efficiency in Energy Intensive Industries* in body of the federal program *"Energy Conservation in Russia for 1998-2005"*. But no concrete policies were specified in this program.

Below several crucial aspects of this program are discussed. The most difficult problem to deal with is the institutional aspect of the program realization. There are no powerful institutions capable to lobby this program. To implement this program substantial financial resources are required. There is lack of institution able to assist industrial plants in developing feasibility studies and business plans.

April hearings on energy efficiency in the State Duma committee on industry, construction, transport ad energy show little interest of congressmen in supporting energy efficiency in industrial sector. Until recently there was no ministry of industry in Russia. Just a month ago new Ministry of Industry and Foreign Trade was established. Therefore, industrial energy problems for a long time were far from focus of government policy.

Only recently federal government recognized the importance of such problems. Several correct steps were made. Some energy prices reductions were introduced. But energy efficiency again was not given proper status of the important force driving energy costs down.

There are departments of industry in many regional governments. They devote more attention to the real industrial problems.

In western countries there are many industrial associations lobbying interests of industry. In Russia in energy field there is just one—Russian Energy Managers Association (REMA), which will be discussed below.

Program implementation should be handled either through Industrial financial groups, or through regions. No other form of coordination of industrial activities exists presently in Russia.

Several initial regulatory actions are to be implemented. Just three to mention from the very long list.

First, it is necessary to cancel present practice of take or pay contracts. This reduces incentives for energy efficiency measures implementation. Second, menu of tariffs should be offered to industrial customers. Fee for exceeding limits set for peak loads are to be canceled. Third, independent power producers are to be able to sell power and heat to the grid for reasonable prices.

6 REMA is a Foothold for Improving the Competitiveness of Russia's Economy

There are many associations of consumers, which play a very important role in shaping markets, including energy market in the US and in many other countries. Association of Energy Engineers (AEE) in the US for over two decades has been an efficient vehicle of bringing representatives of all segments of energy market together being a world recognized institution for education and training.

Russian Energy Managers Association (REMA) was founded on CENEf's initiative as a non-

government, not-for-profit association of energy managers or other persons responsible for energy facilities operation at enterprises, whose activities focus on energy efficiency improvement in the industrial sector and public utility services. CENEf in cooperation with leading energy experts of Russia's enterprises developed the concept for this organization based on the international experience adopted to Russia's. US Agency for International Development provided initial support to this initiative under its program of energy efficiency assistance to Russia.

REMA Charter Meeting took place December 14, 1995 in Moscow. On March 1996 REMA was officially registered. Membership campaign was launched.

Presently REMA associate 60 members including several enterprises listed among the largest Russian industrial enterprises: Izhorskie Zavody (St. Petersburg); Moscvitch (Moscow); Motovilikhinskie Zavody (Perm); Karelsky Okatysh (Kostomuksha); ZIL (Moscow); Kaprolaktam (Dzerzhinsk); VAZ (Toliatty); Posprom (Moscow). There are a number of REMA associated members—Russian or foreign manufacturers of energy-efficient equipment/materials/services, foreign energy managers associations—including Honeywell, Hagler/Baily, Inc; Danfoss, Alfa-Laval.

Over 2000 Russian energy managers took part in two Congresses and many seminars conducted by REMA and CENEf: Legal aspects of energy contracts; Automatic industrial energy consumption control systems; Electric Motors in Industrial Applications; Independent Heat and Power Procures; Energy Audits.

Over 120 chief energy managers of large industrial enterprises were trained at conducted by REMA "Energy Management Training Courses".

Every two months such courses are conducted be REMA in cooperation with Moscow Energy University. Energy managers from hotel Radison-Slavyanskaya, Tabasco factory "Yava", money printing enterprise "Gosznak", Moskabelmet and others came to training courses from all over Russia: Moscow, Ural, Sakhalin, Yakutia.

Publication of REMA quarterly bulletin "Energy Manager" provided invaluable informational support to industrial energy managers at their day to day work. 1000 copies of the *"Energy Manager"* bulletin are mailed around Russia and are disseminated at REMA seminars.

On constant basis REMA provided juridical consultation to its members, including disputable provisions of energy contracts. REMA members are updated by the REMA on new normative and legislative acts with potential impact on their enterprise. REMA is already playing role in the development of energy policy in Russian Federation. Ministry of Fuel and Energy, Glavgosenergonadzor, Federal Energy Commission are presenting there normative acts to REMA for comments before adopting them. REMA President spoke at the Meeting chaired by Vise Prime-Minister Nemtsov on reorganization of natural monopolies.

REMA President was appointed a member of Interagency Expert Committee of Federal Energy Commission.

REMA has established contacts with Russian government and non-governmental organizations.

REMA president—M. Berner—met with Chairman and Vice-chairmen of Federal Energy

Commission, Deputy minister of Fuel and Energy, Mayor of the city of Moscow, Head of Energy inspection. During those meetings many problems with which energy managers are encountering were discussed and some of them were solved.

REMA was invited to comment on the Electricity and Heat Use Regulations. Due to REMA press new versions of energy contracts with electric utilities are becoming place industrial enterprises in more equal position with utilities. REMA was invited to take part in Duma (Russian congress) hearings on energy situation.

That is just beginning of the road. Only few meters of this road were paved. Much needs to be done. Russian industry is able to buy time by studying experience gained in other countries.

Industrial Electricity Efficiency Programs in Brazil[†]

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Summary

This paper reviews the efforts made with industrial electricity conservation programs and policies in Brazil in the recent past. The principal end uses in the industrial sector are considered. The status of various electricity-saving measures is examined along with initiatives developed by the National Electricity Conservation Program (PROCEL), utilities and other agencies. While some progress has been made, there remains enormous potential for cost-effective efficiency improvements. We conclude with a discussion of strategies for intensifying electricity conservation efforts in the future, emphasizing that any policy aimed at improving Brazil's overall industrial electricity efficiency should concentrate not only on the reduction of the specific electricity consumption of particular industrial sectors but also on the rethinking the very strategy for the integration of the country's economy in the global market with respect to the share of electricity-intensive goods out of total exports.

1   Introduction

Electricity use has changed dramatically in Brazil over the past 25 years. Total electricity consumption in Brazil grew from 38 TWh in 1970 to 277 TWh in 1996 (MME, 1988; 1996), an average growth rate of 7.9% per annum, or more than twice as fast as that of the corresponding OECD rate of 3.5% per annum for 1971-90 (Pearson, 1996). The share of electricity consumption in the overall energy mix, counting all electricity based on the energy required to generate power in thermal power plants, grew from 16.0% in 1970 to 38.7% in 1995 (MME, 1988; 1996). Figure 1 shows the evolution in electricity demand and electricity demand per unit of GDP for the 1980-96 period. Overall, the electricity intensity of the Brazilian economy increased 63% between 1980 and 1996, or some 3.2% per annum on average.

[†]This paper draws heavily on Geller *et al.* (1998) and Machado and Schaeffer (1997).

Figure 1. Trends in electricity consumption in Brazil

Source: Based on MME (1996)

Total electricity consumption (Y1) — — Electricity consumption per unit of GDP (Y2)
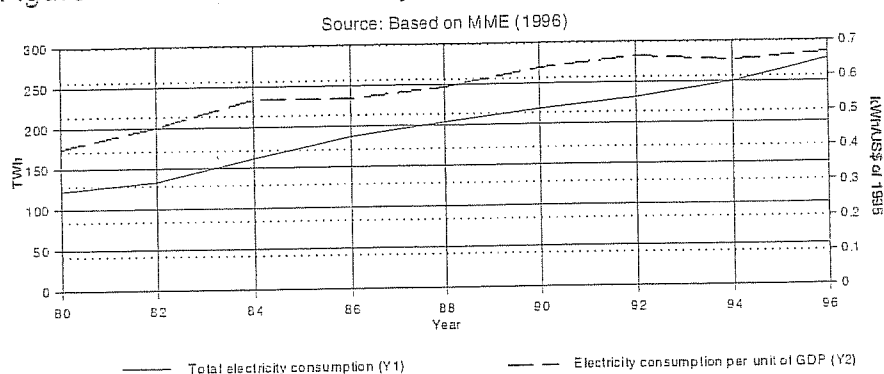
Figure 2. Electricity demand by sector in Brazil

Source: Based on MME (1988, 1996)

Residential · Commercial · Public services · Industrial · Others
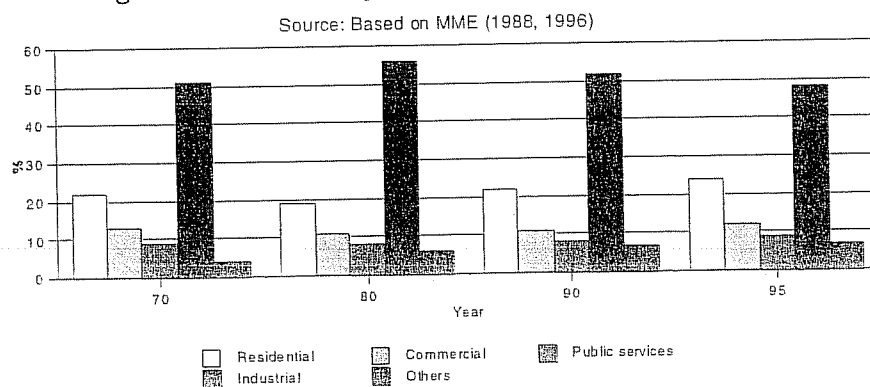
Power sector official estimates traditionally overestimate future electricity demand in Brazil. For example, the decade plan issued by Eletrobras, Brazil's national utility holding and coordinating company of the power sector, in 1989 forecast total electricity consumption of 302 TWh in 1995, nearly 15% more than the actual consumption that year.

Electricity prices in Brazil fell during the 1970s, 1980s and early 1990s (MME, 1996), encouraging demand growth and creating severe financial problems for electric utilities. However, prices were increased significantly in the mid 90s. The prevailing average electricity tariffs in 1996, excluding taxes, were about US$48/MWh for industrial customers, US$98/MWh for commercial customers, and US$105/MWh for residential customers, or some US$71/MWh for the economy as a whole (Eletrobras, 1997). Thus tariffs are not low by international standards and are adequate to cover operating costs. Even so, they are not adequate to cover the enormous debt service and capital investments required by the Brazilian power sector.

To better understand the major industrial electricity conservation opportunities in Brazil, we need to know how electricity is used in the country. Figure 2 presents estimates of electricity consumption by the major sectors of the economy for the period 1970-95. The share of the different sectors was relatively constant during this time period. In 1995, for example, the industrial sector accounted for about 48% of total electricity consumption, the commercial sector for 12%, the residential sector for 24%, the public services sector for 9%, and the

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remaining of the economy for 7% (MME, 1996).

In the remainder of the paper, we describe the efforts undertaken to stimulate greater efficiency and the results achieved with industrial electricity conservation programs and policies in Brazil in the recent past, including initiatives developed by the National Electricity Conservation Program (PROCEL), utilities and other agencies. We then look in detail at the status of electricity conservation measures in industry. Finally, we discuss the main barriers inhibiting industrial energy efficiency improvements and some strategies to overcome them.

2   Electricity Conservation and DSM Programs Initiatives

In the course of the 70s and 80s, the economy of Brazil underwent a period of consolidation of its industry, implementing the major base sectors of the manufacturing sector (iron and steel, non-ferrous metals, basic and intermediate petrochemicals, and pulp and paper industries) on a large-scale (Castro and Souza, 1985; Batista, 1987; and Teixeira, 1993). This phase of the industrialization process characterizes and determines a mature industrial mass production stage (Bell, 1976; and Spreng, 1993), and, ultimately, the very stage of development of the Brazilian economy. As a function of the economic-technological specificity of the base industries, the generally observed patterns of energy use during this stage of industrialization point to a more energy-intensive production (the climbing of the so-called economic development "hill" (Berrah, 1983), leading to an overall increase in the average energy intensity of the economy (Strout, 1985; and Williams, Larson and Ross, 1987).

In the case of industry as a whole in Brazil, the rising energy intensity does not seem to have been caused by increasing energy intensities of particular industrial subsectors but by structural effects alone (Geller and Zylberstajn, 1991; and Francisco Jr., 1995). In fact, in the course of the past 20 years the general long-term trend for the average energy-intensity in Brazilian industry has been one of continuous growth, much of it due to the fact that in the last decades Brazil has progressively secured a place in the international market as a provider of energy-intensive goods (Machado and Schaeffer, 1997).

The concern with the efficient use of electricity in Brazil began in the mid-eighties. Led by the power sector, the objective was to reduce the need for new investments due to the power sector's financial problems.

The Government of Brazil established PROCEL in December, 1985. PROCEL funds or co-funds conservation projects carried out by state and local utilities, universities, state agencies, private companies, and research institutes. These projects involve research and development, demonstrations, education and training, marketing, direct installation of conservation measures, support of ESCOs, work on legislation, and DSM programs. Also, PROCEL helps utilities obtain low-interest financing for major energy efficiency projects from a low-interest loan fund within the electricity sector.

During its initial eight years (1986-93), PROCEL spent a total of about US$24 million on over 100 projects. PROCEL also received an equivalent amount of support for staff, overhead, and travel from Eletrobras. However, Brazil's electric sector experienced severe financial difficulties during the early 90s because of low electricity prices and high debt. Consequently, PROCEL's budget was relatively low and influence relatively limited during 1990-92. A process of renewal was begun in 1993 and continued through 1997. PROCEL's "core budget"

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of grant funds and staff support increased to around US$10 million per year by 1995-96, and reached some US$40 million in 1997. In addition, PROCEL arranged about US$21 and US$42 million of financing for utility energy efficiency projects in 1995 and 1996, respectively, and approved new investments in the amount of US$110 million in 1997.

A comprehensive project review and impact analysis estimated that PROCEL can take credit for about 790 GWh per annum of electricity savings due to actions in 1996 alone and 2,360 GWh per annum of electricity savings in 1996 based on cumulative actions (Geller *et al.*, 1997a). The latter is equivalent to 0.9% of total annual electricity consumption in 1996. Considering cumulative actions, about 43% of the savings come from more efficient refrigerators/freezers; 22% from lighting efficiency improvements; 15% from audits, sectoral studies and seminars and industrial awards; 11% from installation of meters; 7% from motors projects; and 1% from education programs.

The electricity savings resulting from PROCEL's activities have been growing very rapidly (see Figure 3). The savings estimate in 1996 is 53% greater than the savings estimate in 1995, considering actions taken annually. Also, savings from actions in 1996 are about four times as large as the savings from actions stimulated by PROCEL as of 1993. The increase in electricity savings is attributed to the rapid growth in PROCEL's budget, projects, and influence during 1993-96, as well as to the cumulative impact of working in some areas for more than a decade.

Figure 3. Electricity savings due to the actions of PROCEL

Cumulative actions refer to savings since 1986. Source: Based on PROCEL (1997)
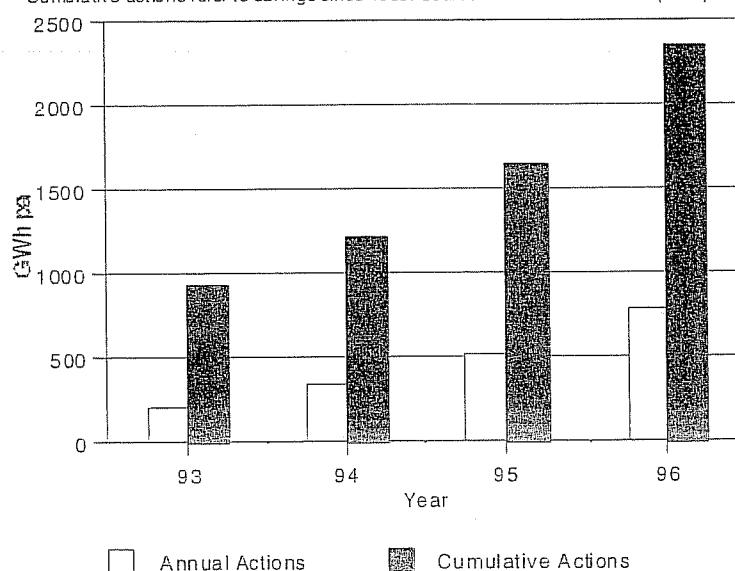
The 2,360 GWh per annum of energy savings produced by PROCEL as of 1996 is equivalent to the power typically supplied by about 565 MW of hydro capacity in Brazil. Assuming an average marginal cost of US$2,000/kW installed (including generation as well as associated T&D investments), PROCEL has reduced supply-side investment requirements by about US$1.1 billion.[1]

Industrial sector. The industrial sector (excluding energy production) accounted for 48% of

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[1]PROCEL also has undertaken some projects to increase power generation at some hydro plants. The results of these supply-side actions are not included here.

total electricity use in Brazil in 1995 (Figure 2). Similar to the other sectors of the economy, the overall electricity intensity of the industrial sector rose substantially during the past 26 years. It is estimated that electricity is used within the industrial sector mainly in motors (51%), electrochemical processes (21%), electrothermal processes (20%), refrigeration (6%), and lighting (2%) (Pinhel, 1994).

Industrial structure. Growing industrial electricity use has been caused primarily by economic growth and structural shifts, not by declining energy efficiencies (Geller and Zylbersztajn, 1991; Henriques Junior and Schaeffer, 1995). Table 1 presents a breakdown of industrial electricity use by major industry type in 1970 and 1995. As of 1995, the most important industries were nonferrous metals (mainly aluminum) (22% of total industrial electricity consumption), chemicals (12%), iron and steel (11%), food and beverages (10%), paper and pulp (8%), and steel alloys (5%); industries that devote a substantial share of there production for export (Machado, 1996; Tolmasquim *et al.*, 1994). These six industries alone consumed about 68% of total industrial electricity use in Brazil in 1995, up from approximately 60% in 1970.

Table 1. Industrial electricity use

Subsector	1970		1995	
	GWh	%	GWh	%
Iron and steel	1,927	9.9	14,222	11.1
Steel alloys	574	2.9	6,406	5.0
Nonferrous metals	3,414	17.5	28,715	22.5
Chemicals	2,646	13.5	14,871	11.6
Food and beverages	1,757	9.0	12,727	10.0
Paper and pulp	1,667	8.5	9,923	7.8
Others	7,550	38.7	40,867	32.0
Total	19,535	100	127,731	100

Source: Based on MME (1988, 1996)

The crux of the matter is that the worsening of the Brazilian external balance of payments in the 80s forced the country into a process of redirecting ever-growing portions of the domestic industrial production towards the international market (Table 2). By oversizing the energy-intensive industrial sectors, the mode of integration of the Brazilian economy into the global market is a decisive contribution to the notable hypertrophying of the energy profile of the national industry, making more steep the economic development "hill" in Brazil. And as a consequence, a significant portion of the energy used by industry is being transferred abroad through the export of industrialized goods. In 1971, for example, the quantity of energy embodied in industrial goods for export represented no more than about 5% of the total energy used by the country's industry, while in 1994 it reached some 29% (Machado and Schaeffer, 1997).

Large industries pay relatively low electricity tariffs, typically US$0.025-0.035 per kWh on average, with the exact price depending on voltage level and load factor. Very large aluminum producers, in particular, have been encouraged to expand smelting facilities in Brazil through special low-cost electricity tariffs. Large industries vigorously resist efforts that would increase energy costs.

Table 2. Shares of industrial exports on total industrial value added and for selected industrial sectors (%)

Industrial sectors	1975	1980	1985	1990	1994
Food and beverages	26.9	43.4	32.8	26.6	25.9
Textile and leather	11.8	13.3	17.7	19.3	28.9
Metallurgy	5.6	13.7	25.6	37.5	38.1
Non-metallic minerals	1.1	3.0	3.1	3.7	4.3
Pulp and paper	6.9	26.9	19.4	30.4	33.2
Chemicals	2.6	8.3	15.2	18.6	21.8
Others	6.8	10.9	13.9	13.8	16.8
Total industry	8.6	14.2	17.3	18.7	21.6

Source: Based on Machado and Schaeffer (1997)

In spite of this, there have been some improvements in the energy efficiency of these industries, particularly in companies concerned about global competitiveness.

Table 3 shows the trends in electricity intensity of the major electricity-consuming sectors since 1975. Two of the largest electricity-consuming sectors—nonferrous metals and chemicals—significantly reduced their electricity intensity during this time period. The increase in specific electricity consumption in some industrial sectors can be attributed to the substitution of electricity for other energy sources rather than to a decrease in efficiency with which electricity is used. For example, between 1975 and 1995 electricity increased its share of total primary energy consumption from 20% to nearly 25% in the iron and steel industry, from over 34% to nearly 43% in the paper and pulp industry, and from 55% to almost 79% in the textile industry, counting all electricity based on the energy required to generate power in thermal power plants (MME, 1988; 1996).

Motors and motor systems. Motors account for about half of industrial electricity use, 40% of electricity use in commercial buildings (mainly through air conditioning, refrigeration, and pumping equipment), and 40% of residential electricity use (through refrigerators and other appliances).

Table 3. Specific electricity consumption in selected industrial sectors (MWh/ton)

Industrial sectors	1975	1980	1985	1990	1995
Cement	0.119	0.120	0.120	0.115	0.116
Iron and steel	0.570	0.587	0.610	0.627	0.567
Steel alloys	5.209	5.438	5.653	6.677	7.182
Chemicals	0.622	0.481	0.530	0.499	n.a.
Nonferrous metals	23.037	19.157	17.145	17.677	16.060
Textile	1.885	2.327	2.905	n.a.	n.a.
Paper and pulp	0.798	0.824	0.896	0.899	0.878

Source: Based on MME (1996)

Approximately 1.2 million three-phase and 6.0 million monophase motors are sold annually in

Brazil (Soares and Tabosa, 1996). Three domestic manufacturers, the largest of which has a 60-70% market share, make most of these motors.

Brazilian manufacturers started producing high efficiency motors containing silicon steel and other improved features for export in the 1980s (Geller, 1991). The manufacturers began selling these motors in Brazil around 1990. During the early 1990s, motor manufacturers increased the efficiency of both their standard and high efficiency motor lines (Oliveira and Almeida, 1995). Figure 4 compares the efficiency of typical standard and high efficiency induction motors made in Brazil in 1996 in the range of 1-200 HP. For smaller size motors, the different in efficiency is 5% or more, while for larger motors the difference is 2-3%. High efficiency motors represented only about 1% of three-phase induction motors sold in Brazil in 1996 (Geller *et al.*, 1997a). Furthermore, high efficiency motors made and sold in Brazil are somewhat less efficient than high efficiency North American motors, as evidenced by comparing Brazilian high efficiency motors with the thresholds used for designating "Premium Efficiency" motors in North America (see Figure 4).[2]

Figure 4. Comparison of the efficiency of electric motors
Brazil vs. North America. Source: Based on Tabosa (1997)

—— —   Average Brazilian standard motor
————   Average Brazilian high-efficiency motor
·······   Threshold for "Premium Efficiency" motors in North America
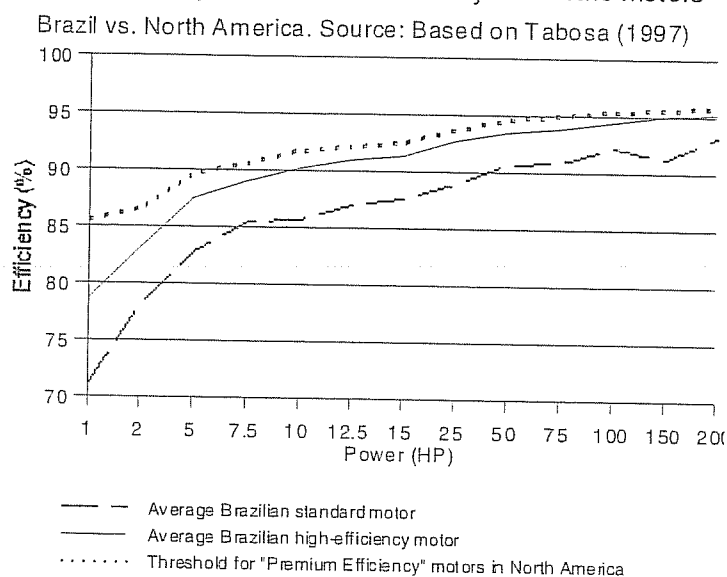
High efficiency motors typically cost about 40% more than standard motors sold in Brazil (Soares and Tabosa, 1996). Nonetheless, high efficiency motors are cost effective in many applications when a new motor is needed, with a cost of saved energy of $0.015-0.025 per kWh saved (Soares, Hersztberg and Arouca, 1996). The simple payback period ranges from 1 to 7 years, depending on the size of the motor and the electricity tariff. But the extra first cost, lack of familiarity, and lack of a well-developed delivery infrastructure (i.e., high efficiency motors are not normally stocked by motor distributors) all contribute to the very low market share for high efficiency motors.

Besides the low efficiency of electric motors in Brazil, there are two additional factors that add to poor performance of motors in the industrial sector: improper specification (use of oversized motors), and poor operation and maintenance practices. Field surveys in the late 1980s showed that around 71% of all motors in use in industry operate at loads under full capacity, and 25%

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[2] The test procedures for rating the efficiency of motors in Brazil are very similar but not totally identical to the test procedures used in North America.

at loads under 50% of full capacity, resulting in lower efficiencies (Henriques Junior, 1995). The use of energy-efficient motors and motor speed controls, along with regular preventive maintenance practices and use of appropriate voltage and power factors, can significantly reduce electricity use in motors. For example, one study estimates a cost-effective savings potential of about 12 TWh (20%) in industrial motor systems after a ten-year DSM effort (Geller, 1991).

PROCEL has sponsored a number of projects in the motor systems area, including studies of the level of inefficient practices such as oversizing; demonstrations of adjustable speed drives in applications with a high degree of part load operation; development of higher efficiency motors; adoption of standardized motor efficiency testing and labeling; and development of data bases and software, and guides to help businesses and industries increase motor system efficiency. Efficiency labeling began for 1-200 HP induction motors in 1996. Also, the PROCEL "seal of approval" was given to the most efficient standard motors sold starting in 1995, leading to some efficiency improvements in new motors in 1996.

It is estimated that motor efficiency improvements stimulated by PROCEL in recent years resulted in savings of about 170 GWh per annum as of 1996 (Geller et al., 1997a). The savings are limited in part because PROCEL's most influential efforts in this area are relatively recent, and in part because the market share for high efficiency motors is still very low in Brazil. More needs to be done to encourage energy savings in this important end use.

Overall efficiency potential. For industry as a whole, PROCEL's audit program indicated a savings potential of 8-15% based on low-cost measures like replacing oversized motors, improving transmission systems between motors and subsequent equipment, replacing overloaded lines, adjusting or replacing overloaded transformers, correcting low power factors, correcting electrical problems, and using more efficient lamps or light fixtures (Geller, 1991). Additional savings are possible through the use of energy-efficient motors, variable-speed drives, improving electric furnaces and boilers, electrolytic processes improvements, and cogeneration system, but these measures are more costly (Henriques Junior, 1995).

CEMIG, the electric utility in Minas Gerais state, has promoted more efficient electricity use among their major industrial consumers through information dissemination. CEMIG first performs a detailed audit in one or more companies, followed by seminars for many companies in the same sector in order to disseminate the audit results (Nobre, 1996). CEMIG then collects data on measures implemented and electricity savings achieved by companies that attended these seminars. During 1991-96, CEMIG conducted these studies and seminars in 10 sectors, with a total electricity savings of 161 GWh per annum reported (PROCEL, 1997).

Some companies have made major strides in increasing their energy efficiency. A large tire production plant owned by Pirelli of Brazil, for example, cut its electricity use per ton of output by 28% between 1992 and 1996 through installing high efficiency equipment, cutting losses in air compressor systems, and other measures including adopting an employee suggestion and cash prize program (Bahia Indústria, 1997). Pirelli, which received a National Energy Conservation Award in 1997, claims this plant in the state of Bahia is now the most energy-efficient of its 74 facilities worldwide.

3 Discussion and Recommendations

There is an enormous potential for reducing industrial electricity use through cost-effective end-use efficiency improvements in Brazil. Many efficient technologies, such as high efficiency motors and lighting products, are now produced and/or marketed in Brazil. In addition, design and operational changes such as more careful equipment sizing, use of natural lighting and ventilation can reduce electricity use and peak loads. Adoption of these energy efficiency measures and practices is growing, but in most cases has penetrated less than 5% of the eligible market.

But, it any case, the smaller the gains in electricity efficiency in the various industrial subsectors the greater will be the influence of the mode of external integration of the Brazilian economy on the patterns of energy use in the country's industry as a whole as well as on its average level of energy efficiency. In other words, a more energy-intensive mode of international integration for Brazilian industrial exports may endanger the effectiveness of measures aimed at promoting the more efficient use of electricity in the Brazilian industry in the future (Machado and Schaeffer, 1997).

Energy efficiency improvements in Brazil are inhibited by a series of market barriers and imperfections, including:

1. many decades of economic instability and high inflation, conditions which strongly discouraged life-cycle analysis and longer term investing, and led to purchases based on minimum first cost;
2. due to industrial policy relatively closed markets and lack of competition, which reduce incentives to cut costs;
3. lack of awareness of electricity conservation measures and practices on the part of end users, due in part to the recent introduction of many of these measures;
4. immature energy efficiency delivery infrastructure, again related to the recent introduction and limited adoption of many measures;
5. subsidized electricity prices still paid by large industrial consumers;
6. electricity representing a relatively small portion of total costs for most industries;
7. lack of capital or attractive financing for many industrial consumers—interest rates are generally very high in private markets and borrowing is discouraged by heavy bureaucracy, onerous guaranty requirements, etc; and
8. lack of financial incentives for utilities to operate demand-side management (DSM) programs that lead to significant electricity savings by industrial consumers.

A number of these barriers have been reduced in recent years. Inflation has greatly decreased and overall economic conditions have improved since the adoption of the Plano Real[3] in 1994. Markets have been opened up and competition is expanding. Many industrial consumers are now paying relatively high electricity prices. And the availability and awareness of efficiency measures is increasing, in part due to the efforts of PROCEL.

However, much more could be done to promote efficient electricity use given the savings potential, the high growth in electricity demand in recent years, and the increasing risk of power shortages in Brazil. Indeed, PROCEL has set targets of saving 2.1 TWh per annum in

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[3]The Plano Real was the successful economic stabilization plan which greatly reduced inflation in Brazil.

1997 and 2.7 TWh per annum in 1998, well above the levels achieved in recent years (see Figure 3). In order to increase the efficiency of electricity use on a wide scale, we recommend that a combination of public policy instruments be used including regulations, financing mechanisms and ESCO support, utility DSM programs, and broad information dissemination and marketing campaigns.

Regulations

In Brazil, adoption of efficiency standards has been through negotiations of voluntary targets with electrical equipment manufacturers. So far, this approach has given mixed results. In the future, it would be helpful if the government had the authority to adopt mandatory efficiency standards as has been done in the United States. Legislation permitting this was introduced in the Brazilian Congress in the early 1990s but has been stalled. This legislation should be updated, reintroduced, and strongly supported by energy planners and policy makers interested in both increasing economic efficiency and reducing the risk of future power shortages.

In the absence of legislation specifically setting or calling for minimum efficiency standards, it is possible to adopt minimum efficiency requirements as part of technical norms. These norms are used to certify products and are used by many industries in purchasing goods such as motors or lighting products. But these norms are adopted through a consensus process, and many manufacturers resist stringent efficiency requirements.

Financing and ESCO support

The lack of financing and high cost of capital are another barrier that needs to be addressed. One way to do this would be to incorporate energy efficiency requirements as part of financing for industrial expansion (Hollanda et al., 1994). In fact, the national development bank (BNDES) is attempting to finance energy efficiency projects in conjunction with loans for industrial expansion (Mello, 1997).

As noted above, many ESCOs have begun operating in Brazil. However, there is little experience with performance contracting or third party financing for ESCO projects. Most projects are small, and nearly all projects are being implemented using financing provided by the client. In a few cases, financing of lower cost measures is provided by the ESCO itself (Poole and Geller, 1997).

A number of steps are being taken to increase the availability and amount of third party financing for energy efficiency projects. First, PROCEL and local utilities are starting to finance ESCO projects from a low-interest loan fund in the electricity sector. Second, PROCEL is working with the national development banks to establish practical financing for both ESCOs and consumer-sponsored energy efficiency projects. The national development banks have indicated willingness to finance efficiency projects, but financing has been inhibited by relatively small project size, administrative requirements, limited interest on the part of local banks (who process smaller loans for the development banks), and high collateral requirements. Efforts to overcome these barriers should continue.

Other actions that could help to expand the ESCO industry in Brazil include establishing an energy efficiency loan guarantee fund, developing and disseminating model energy performance contracts, developing monitoring and savings verification procedures, providing training and independent certification of ESCOs, and publicizing successful ESCO projects. A number of organizations are working on these issues, including a Brazilian ESCO association that was started in early 1997.

Utility DSM programs

Electric utilities could play a much larger role in promoting more efficient industrial electricity use in Brazil. First, PROCEL should receive additional resources (both funding and staff) in order to stimulate greater adoption of efficiency measures and market transformation in key areas such motor systems. PROCEL hopes to scale up its activities in 1998-2001 in part by obtaining a large loan from the World Bank and accompanying grant from the Global Environmental Facility. These funds would be used for state and local implementation programs, pilot projects, and core activities such as training, information dissemination and marketing, and equipment testing and standards.

Second, state and local utilities should increase their own end-use energy efficiency programs. A growing number of distribution utilities in Brazil are starting DSM programs. These programs are aimed primarily at reducing peak load in specific regions in order to postpone costly T&D system investments. This strategy has been successfully pioneered by CEMIG in one part of Minas Gerais state (Nobre, 1996).

This situation can and should change in the near future as government-owned utilities are privatized and utility sector restructuring takes place. As part of this restructuring, we recommend that:

(a) all distribution utilities be required to set savings targets and operate DSM programs for their customers, working closely with PROCEL;
(b) both local DSM programs and PROCEL receive base funding through a distribution system "wires fee" (e.g. 1% of retail revenues), which would serve as a floor but not a cap on utility energy efficiency investments;
(c) distribution utilities be allowed to recover costs, net loss revenues, and a portion of societal benefits produced by their DSM programs; and
(d) energy savings projects be allowed to participate in energy resource bidding processes conducted by utilities or independent systems operators.
(e) Given that a few distribution utilities have already been privatized and many more utilities are expected to be privatized in the next few years, it is especially important to provide utilities with financial incentives for operating end-use energy efficiency programs that are in the national interest. Some of these policies have been recommended by the international consultant advising the government of Brazil on utility sector restructuring.

Education and marketing

Consumers need to be educated and convinced that increasing energy efficiency is worth the effort, even if energy use represents only a small fraction of the cost of operating a business. This barrier exists in all countries and will not be easy to overcome in Brazil, where consumers face a host of problems in addition to those experienced in industrialized nations. On the other hand, if major steps are not taken to both increase electricity supply and improve energy efficiency in the coming years, it is likely that power shortages will occur. This prospect could be used as a "rallying cry" for stimulating consumer action.

Raising awareness of energy efficiency opportunities is needed among industrial consumers. Many industries in Brazil are trying to cut their costs and improve their competitiveness, but are not aware that energy efficiency measures often provide a higher rate of return than other investment options.

PROCEL has sponsored educational and information dissemination programs for all types of consumers, and is planning to greatly expand its advertising and marketing efforts starting in

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1997. Information on successful case studies and best practices could be disseminated to industrial consumers. Likewise, energy efficiency training is needed for architects, plant and building engineers, and other professionals who influence energy use.

Finally, it could be helpful to connect efficient electricity use with environmental protection. Concern about the environment has greatly increased in Brazil in the past decade. However, since over 90% of electricity in Brazil is provided by hydropower, there is little recognition that electricity waste is harmful to the environment. But this view is incorrect because hydroelectric dams often have significant adverse environmental impacts (Rosa *et al.*, 1988; Rosa and Schaeffer, 1995), and because new power plants will increasingly depend on fossil fuels. Associating efficient electricity use with a cleaner environment could help to stimulate additional industrial consumer interest and action.

4   Acknowledgments

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Industrial Energy Efficiency Programs in India

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1   Introduction

India has one of the highest quotients of energy to gross domestic product (GDP). Energy cost is also one of the highest in India. The growth rate of energy demand has been brisk and is about 10 percent per annum. The domestic primary energy sources have not kept pace with demand with the result that the dependence on imported primary energy is increasing. Presently, the import of crude oil almost matches the domestic production of 34 million tones. By the year 2002, the import bill on energy is likely to be around $20 billion.

The industrial sector is the major energy-consuming sector in India and uses about 50% of the total commercial energy available in the country, and contributes to 25% of the GDP. The total industrial energy consumption has grown at about 5 percent per annum and is about 86 mtoe presently. Perennial power shortages and unreliable grid supply have forced larger industry to install 100% standby captive power plants, adding substantially to their investments.

In general, Indian industry is highly energy intensive and energy efficiency is well below industrialized countries. Efforts to promote energy conservation in the industrial sector could not only save substantial amounts of energy but also reduce the cost of production, making the industries globally competitive. Various studies indicate that the potential for energy conservation in the industrial sector is about 20 to 25 percent of overall energy consumption. Although energy conservation has been recognized as a key element in bridging the gap between energy supply and demand, energy efficiency has not made any significant impact in our national plans. Though a number of initiatives have been taken by the government, more in nature of constitution of committees and departments, energy efficiency has been one of those areas where rhetoric exceeds action. A coordinated effort among the different energy related ministries to devise an integrated energy policy has been lacking.

This paper outlines some of the important government programs on industrial energy efficiency and effectiveness of the various policies to promote energy conservation.

2   Government Initiatives

The cost of saving energy through energy conservation measures is much less than the investment required creating equivalent resources. The government realized this way back in the early seventies in the post oil crisis period and energy conservation studies were initiated in several hundred industries soon after. Subsequently, in 1976, the Petroleum Conservation Action Group was set up which is presently known as Petroleum Conservation Research Association (PCRA). In the eighties, several high-powered committees were setup like the

Inter-ministerial Working Group (IMWG) on utilization and conservation of energy in 1981 and the Advisory Board on Energy in 1983. These groups, through its high powered structure, created some impact on the need for energy conservation. The Inter-Ministerial Working Group Report of 1983 is the most comprehensive policy document on energy conservation published so far and is still referred to by policy makers.

In the eighties, several important government departments were set up, dealing with different aspects of energy. The Department of Non-Conventional Energy Sources came into existence in 1982, which later became a full-fledged ministry. In 1984, the department of power (now Ministry of Power) was identified to be the nodal agency for energy conservation. A post of Adviser (Energy Conservation) was created and an autonomous organization, under Ministry of Power, to assist in energy conservation programs, called the Energy Management Center (EMC) established.

However, the short life of some of these committees, proved once again the lack of strategy of the government on energy efficiency as a whole. The Advisory Board of Energy lasted five years, the post of Adviser (Energy Conservation) was abolished within three years of its formation and the EMC, which was setup in 1989, is presently being dismantled.

3   Financial Instruments

In order to motivate the industrial sector to take up energy conservation seriously, the government has, from time to time, introduced financial instruments like subsidies, depreciation allowances, and tax exemptions and soft loans.

Local financial institutions and organizations like PCRA and Indian Renewable Energy Development Agency (IREDA) initiated most of the schemes extending loans at concessional rates. In 1982, PCRA started a boiler modernization scheme, in which industry was eligible for loans 8% rate of interest to for boiler modernization, which were almost 10% below the prevailing market interest rates. The government has launched soft loan facility for a number of renewable energy based applications. Loans up to 85% of project cost at attractive rate of interest (2.5-5.0%) for power generation from renewable energy sources are available from the government. The purpose of the soft loan scheme were to give an initial boost to adoption/promotion to new technologies or applications till the industry adopts them on their own merits.

A customs duty and excise duty concession on notified energy conservation equipment devices is another tool adopted by the government to promote energy efficiency. Presently about 25 energy-efficient equipment have been notified. New products or equipment are added deleted to the list from time to time.

Schemes to promote energy audit, by providing direct subsidies towards the audit fee, were launched by government agencies like PCRA and public financial institutions like Industrial Development Bank of India (IDBI) in the mid-eighties.

Programs aimed at performance contracting using shared savings approaches have also been tried by IDBI. Under the scheme, benefits arising out of the energy saving from the scheme would be shared in a predetermined agreed ratio. However such schemes have failed to take off, primarily because of the apprehension of industry on quantification of actual energy savings from the measure.

The most popular financial instrument, by far, has been the 100% depreciation in the first year for notified energy conservation equipment, which was initiated in 1983 by the government. The number of energy-saving devices are eligible to avail of the scheme are categorized in the following categories:

- Specialized boilers and furnaces e.g. fluidized bed boilers
- Instrumentation and monitoring system for monitoring energy flows e.g. exhaust gas analyzer
- Waste heat recovery equipments e.g. heat pumps, economizers, recuperators
- Cogeneration systems e.g. vapor absorption refrigeration systems
- Electrical equipment e.g. automatic voltage controller, capacitors
- Burners e.g. low excess air burners
- Other equipment e.g. mechanical vapor recompressor, thin film evaporators
- Renewable energy devices

4   Legislative Measures

Energy audits have been made mandatory in some states in India. As per the regulations, all industries in those states, having electrical energy demand of more than 500 KVA, will have to get an energy audit done by an accredited energy auditor submit a copy of the report to the state electricity boards. A national energy legislation has also been formulated and awaiting to be introduced in parliament. Mandatory energy audits are likely to be extended to other states as well in the future.

5   Voluntary Agreements

Although the awareness of energy efficiency is high among the large industry, there is a gap in the top management commitment to energy conservation. In many developed countries, including UK, voluntary top management commitment programs have paid rich dividends. Unfortunately, there is no parallel program in India. Although several individual industries have made remarkable progress in energy conservation due to management commitment, there have been no coordinated effort or information sharing with the industry sub-sectors. There is an immediate need for industry commitment to energy savings through voluntary agreements.

6   Information and Monitoring

The industry associations, particularly those for industrial sub-sectors, have compiled production statistics of industry on a regular basis. However these associations have not performed compilation and updating of plant specific energy data so far. Surveys have been undertaken from time to time by some of the industry associations to gather energy-related data. Success stories of selected industries are also commonly found in industry newsletters and other energy journals. In general the large-scale industries are well aware of energy-efficient equipments. However the awareness of awareness on energy-saving strategies is abysmally low in the medium and small-scale industries, which account for a major share of total energy consumption in India.

Government organizations like the PCRA and EMC are the main channels for dissemination of information on energy-efficient applications and equipment. There have been several other initiatives to promote energy efficiency through seminars, case studies, reward schemes and training programs. Two major ongoing initiatives in this regard need mention. One is the Energy Efficiency Support Project, which was launched by the Government of The Netherlands and the Government of India, through the Asian Development Bank (ADB), and will be completed in 1998. Several agencies like the Confederation if Indian Industry (CII), TERI and EMC are involved in the implementation of various activities like energy and environmental audits, feasibility studies, promotional programs and training programs. Another ongoing initiative is the Industrial Energy Efficiency Project, again launched by ADB, which is aimed at providing financial assistance to energy efficiency and related environmental improvement projects.

However energy consumption data of industrial sub-sectors have are not catalogued on a regular basis making comparisons difficult. There is a need to set up a national data bank on energy consumption of major energy intensive industrial sub-sectors within the country, which monitor the energy performance of the selected industry sub-sectors.

7   R & D Programs

The R&D efforts on energy-efficient technologies have mainly remained confined to the medium and small-scale industrial sectors. In larger industries like, fertilizers, refineries, petrochemicals, synthetic fibers, cement, iron and steel, aluminum, pulp and paper, chlor alkali etc have mainly relied to imported proven technology. The R&D programs of larger industries have been mainly in form of technology adaptation or up gradation including debottlenecking exercises. In complete know-why transfer and lack of local capacity building among local research institutes have lead to reliance on selected imported technology suppliers in the area of energy-efficient technology. The Council of Scientific & Industrial Research (CSIR) monitors the activities of a number of regional research laboratories, but the linkages of these research institutes and industry has been very weak. There have been few specific R& D efforts mainly in form of demonstration projects in medium and small industries with funding from government and/or bilateral and multilateral sources. The replication of the demonstration plants among other industries has been the major problem.

8   Effectiveness of Policies

A review of the various energy conservation programs suggests that many of the many of the policies have failed to have the desired effect. The industrial sectors, which invested on energy-efficient technologies and equipments, did so because of market competitive forces rather than as a result of government policies on energy efficiency. In general large industries have adopted energy-efficient technologies but the medium and small-scale industries are far behind.

The concessions in taxes and duties were designed on the premises that the cost of energy-efficient equipment is higher than standard equipment. Direct subsidy schemes, which put a great strain on the exchequer, have useful to promote a new technology or equipment when it is introduced in the market. One problem of direct subsidy is that there may be many fly-by-night operators out to make a quick buck from the increased market demand. The new

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products are likely to have a high failure rate in the market with the result that the product gets a bad name.

Another example of ineffectiveness of direct subsidy scheme is the energy audit subsidy schemes. The subsidy programs, which had a maximum cost limit, subsidized preliminary energy audits, and also was bureaucratic in administration and implementation. Most companies who were keen on energy savings seldom waited to meet the procedural requirements of the schemes. Moreover, the sponsoring agencies ran out of funds earmarked for the activity within a short time after launch of the schemes, and were not able to extend this facility beyond a few years.

Legislative measures like making energy audits compulsory also backfire. Industries forced to undertake energy audits out of compulsion, had the tendency is to go for least cost option to meet legislative requirements rather than out of a genuine concern for energy savings. Hence the goal of energy saving becomes secondary to the industry and compliance by hook and crook.

The financial instrument that has been very successful with industry is 100% depreciation in the first year. The rebate is easy to claim for the industry and can be administered easily without any bureaucratic procedures.

9   Conclusions

The energy scenario in India will be characterized by increasing energy shortages on one hand and the rising cost of energy on the other. The imposition of international environmental regulations would also force industry to adopt latest low polluting technologies. Energy conservation offers enormous opportunities as the least cost option for bridging the ever widening gap between demand and supply. Efforts to promote energy conservation could lead to substantial reduction of the cost of production, making the industry competitive.

Partnerships between government, industry, financial institutions and R&D institutes in the area of energy efficiency improvement could result in effective promotion of industrial energy efficiency. Policies on energy efficiency improvement should also address the issue of local capacity building of energy-efficient technologies through adaptive R&D. Information dissemination mechanisms among industry sub-sectors need to be strengthened especially on the benefits accrued due to adoption of new energy-efficient technologies. Voluntary agreements on top management commitment to energy savings must be encouraged. Fiscal incentives like tax concessions would be the trend instead of subsidies. Energy efficiency programs would be effective when the industry starts realizing the usefulness of energy savings as a tool to increase profits and productivity, rather than as a statutory requirement.

Overview of Industrial DSM Programmes

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1   Introduction

Electricity has been one of the essential ingredients to achieve industrial development and to raise the standard of living of modern societies. Electricity consumption has been increasing exponentially for most of this century and the associated undesirable impacts of this growth became more visible. Those impacts include:

- Environmental impacts both at regional and at global level.

- Depletion of non-renewable energy resources.

- In some countries the expansion of the electricity supply system to cope with a fast growing demand led a large financial debt of the utilities.

The electricity is converted by a large variety of end-use equipment in industry such as: drivepower (pumps, fans, compressors, conveyors, winders, cranes, mills, mixers, etc.), lighting, electrotechnologies (furnaces, electrolytic processes, lasers etc.), whose efficiency is normally quite far from the theoretical limits. Additionally, in plenty of situations, the investment in high efficiency equipment to reduce electricity consumption is more cost-effective than investing in new power plants. Cost-effectiveness is essentially dependent on the price of electricity, on the relative costs of investing in power plant expansion and in conservation options. A combination of inertia and market imperfections has prevented the most cost-effective solutions from being systematically implemented.

In North America a variety of DSM programmes has been offered to industrial consumers, both for load management and for electricity conservation. Most of the demand-side programmes have been directed to the residential and commercial sectors. The industrial sector has received less attention, not because of the savings potential, but due to the much more diverse and complex electricity conversion processes in industry.

In Europe, most of the DSM effort has been directed towards modifying the load diagram in order to increase the load factor. This has been achieved with a high degree of success through pricing mechanisms, which provide a strong incentive to modify the consumption patterns. Very limited effort has been made by the utilities to promote electricity end-use efficiency, which is mainly due to the lack of a suitable regulatory framework.

In industrializing countries interest has picked in recent few years to promote DSM. One of the main reasons behind this surge of interest is the possibility offered by DSM to slow down the very fast growth of electricity consumption. Brazil is a good example of the countries which are promoting aggressively DSM programmes (Geller, 1997).

2   Industrial DSM Programmes

In conventional electric utility planning the strategy is to meet the forecasted electricity demand by optimizing the mix of supply-side options (including power purchases), as well as the transmission and distribution systems, which can meet demand with a minimum cost. Additionally the planning process must also meet the specified reliability levels, and safety and environmental constraints.

The use of large-scale cost-effective DSM programmes can influence the demand, decreasing the need for capacity expansion and the use of non-renewable resources. Table 1 shows several of the most used options to influence consumer demand (De Almeida et al., 1994).

Table 1. Examples of DSM resource options

Energy-efficiency options (customer):
• Efficient motor systems
• Efficient lighting
• Process improvement
• High efficiency heating,
• Ventilation and A/C
Energy-efficiency options (utility):
• Reduced transmission and
• Distribution losses
• Advanced transformers
• Load management
• Rates:
• Time-of-use
• Incentive
• Interruptive

The introduction and application of DSM programmes by electric utilities can bring a wide range of advantages. Similar benefits can be obtained if DSM is applied in other fields, such as gas utilities. The potential benefits of DSM include:

Greater economic efficiency and profitability. The mix of supply- and demand-side options provided by DSM provides energy services with minimum costs, leading to a decrease of the cost of manufactured goods and services. Industry will pay less for their electricity bills, thus have more disposable income for other purposes and it will be able to increase its profits. As an example if in a typical industry electricity represents 3% of the production costs and the profit margin is 20%, if through DSM activities the consumption drops by 0.5% of the costs, the profits will increase by 2.5%.

More flexibility, less risk and the possibility of more profitable operations for the utilities. DSM can be a win-win situation for consumers and utilities. The need to invest in large power

plants, with the associated financial burden and risks, will be reduced. Cost-effective demand options provide a more flexible and shorter term approach to follow demand.

Substantial reduction of environmental impacts. In terms of the public opinion in developed countries, this seems the strongest argument in favour of the application of DSM. DSM leads to a reduction of electricity consumption, which means that less generation is required, which in its turn leads to a reduction in the emission of pollutants associated with the operation of power plants. Although the emission of certain types of pollutants, such as SO_2 and NOx can be controlled at a cost, there are no technologies available to reduce CO_2 emissions once it is released. Electricity conservation appears as one of the most important strategies to reduce CO_2 emissions, and thus help to reduce the threat of global warming.

DSM takes a more balanced perspective in terms of social benefits. The minimization of the costs of energy services also takes into account externalities such as energy security, economic impacts and environmental impacts, which are increasingly relevant for modern society.

DSM can help to improve the relations between the utility and industrial consumers. To prepare and implement a good DSM plan the utilities must know well the consumer needs. The preparation of custom measures, frequently required in industry, requires the active involvement of the customers. This improved knowledge, as well as the savings provided by DSM, can contribute to improve relations and to provide a better image of the utilities.

DSM can improve the already good load forecasting. The detailed knowledge of the disaggregated electricity consumption of the different sectors, required for the IRP process, can improve the accuracy of load forecasting. This further contributes to a reduction of the investment costs, as there is less uncertainty when planning new investments.

Reduction of the consumption of non-renewable energy resources used in power plants.

A smooth transition to achieve sustainable development in a not too distant future.

Reduction of dependency on imported fossil fuels (gas, coal and oil) leading to greater energy security and to an improvement in the trade balance. In many developing countries, imports of fossil fuels are a heavy burden on their limited foreign exchange capabilities, being one of the main factors for their foreign debt.

Development of new business and employment opportunities. Large-scale implementation of electricity conservation measures will promote the appearance on the market and the penetration of high-efficiency equipment. Energy conservation measures have also been shown to contribute in a positive way to increase employment (Nadel, 1991), not only in activities related to equipment manufacture but also in auditing, installation and evaluation.

3   Why There is a Need For Industrial DSM Programmes

In a perfect market economy with proper price signals, industrial consumers would make the proper decisions in choosing the least-cost demand-side options. Therefore the critics of DSM point out that if DSM is really cost-effective, consumers should need no help from the utility in making cost-effective investments in conservation measures. However a combination of consumer inertia and market imperfections have prevented a stronger penetration of conservation options. Typically, there is a substantial efficiency gap between the energy

efficiency of the average new investment and the efficiency of the most cost-effective options. DSM programmes have demonstrated the capabilities and appears to be the right strategy to overcome those barriers.

The main barriers to energy efficiency for industrial consumers include:

3.1   Lack of Information

Ignorant Consumer. Normally energy-efficient options require extra consumer investments to purchase the technologies, and specific knowledge to make an informed and appropriate decision.

A typical example is the optimization of the drive power used by all types of industries. In order to achieve most of the potential savings it is necessary to look at the whole drive system and match it to the specific application. This requires, in most situations, expert knowledge in several disciplines, which only few industries have.

Savings Difficult to Measure.   It is often difficult for utility customers to know the contributions of individual end-uses from the more general information typically offered on an electric bill. Utilities need to provide considerably more information and technical support if consumers are to have the necessary information to make "rational" decisions on energy use.

3.2   Payback Gap

The "payback gap" is a key impediment to investment in more efficient equipment. The concept is simple. Industrial and commercial customers are likely to make calculations of payback periods when making decisions on the acquisition of new equipment. In general commercial and industrial consumers will invest in energy-efficiency improvements only if the resulting energy savings will yield a simple payback period of two to three years. This contrasts sharply with utility investment perspectives: utilities can invest in power plants that take up to 20 years to payback. This gap in payback requirements causes society to invest too little in energy savings and too much in the supply-side.

Capital Market Imperfections. The market for energy efficiency, determined by the decisions of millions of individual investors, operates at discount rates much higher than electric utilities cost of capital. Utilities are able to borrow money with low interest rates (typically 4-10%). Indeed, in most cases the decision on efficiency choice is made with a discount rate several times greater than the utility cost of capital.

3.3   Consumers Behaviour and Concerns

Scepticism about Savings. Consumers often do not believe the technology performance claimed by manufacturers. Manufacturers often claim savings, which may be exaggerated under certain conditions. This creates some scepticism about technology performance.

Customer Indifference. There are some energy-informed consumers who are indifferent to energy efficiency improvements. There is two major factors account for this attitude:

- energy cost is just one (and often not a very important factor) of many factors (such as brand names, aesthetic appeal, etc.) concerning energy equipment purchases.
- energy costs of these consumers are not so significant to motivate them to implement

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energy efficiency improvements, even thought the savings coming from these improvements are very important to society at large.

The following illustrative example could be useful in order to underline the importance of life-cycling costing and the tendency of users in underestimating all costs other than the direct initial investment: "After 10 years of operation at 4000 h/year, a 1,1kW (11kW) motor accumulates electricity costs more than 14 (respectively 25) times higher than the initial investment costs."

Risk/Corporate Image. Another important customer requirement concerns the reliability. When making a significant purchase, consumers, builders and installers all want to know that the purchase will last for at least 15 years without any problem. But some energy-efficient technologies do not have such extensive track record because they are so new.

3.4   Market Structure

In most industries the customer purchases equipment and sometimes completes production lines, in which the manufacturer of the equipment incorporates different pieces of energy converting components (motors, fans, pumps, compressors, etc.).

Because Original Equipment Manufacturers (OEMs) of those equipments compete largely on the basis of price, they tend to avoid the use of more expensive components. And because they are several steps away from the end-users in the market chain, they rarely receive direct requests for efficiency improvements.

One factor that influences in a significant way a product market penetration is the capability of the product distribution system to make the product available and to supply it to the customer who wants it. If supply cannot keep up with demand, there is a potential for loosing consumer interest to the inefficient options. Also when customers make a purchase, they always choose a model (or brand) that ensures them a reliable repair service in the case of a failure in their new technology.

3.5   Split Incentives

OEMs have no motivation to buy more energy-efficient components because they will not have to pay the bill. Their main concern is price and time of supply. Unlike OEMs, end users have a strong interest in the efficiency of the energy conversion components because they have to pay the energy bills.

3.6   Purchase Decision Criteria

A substantial proportion of those in charge of purchasing power equipment are typically untrained and uninvolved in the energy-use consequences of their choices. They are quite ignorant about energy efficiency costs and benefits. They select products primarily on the basis of price (first cost) and delivery terms, leading to poor or inefficient choices.

For example, discussion over the allocation of resources between managers and technical personnel, or between shareholders and management, may result in biases against energy-efficiency investments.

3.7 Limited Access to Capital

Even an informed consumer who wishes to invest in more efficient equipment may have limited access to capital, for which energy savings must compete with many other potential investments.

3.8 Lack of Internal Incentives

Many firms are organized in some individual departments each one having their own budget. This situation implies the partitioning costs of equipment through the different departments: the purchase department supports the capital for efficiency improvements and the maintenance department supports the operating costs. Thus the purchase department has no incentive to invest in energy efficiency improvements that will reduce operating costs, because this practice just will benefit another department. Besides, there is a lack of internal rewards for departments and/or people to pursue energy-efficient investments.

3.9 Aversion to Downtime and Innovation

It is difficult in most cases to justify replacing operating energy converting components (e.g. motors). It is more reasonable to replace those components when they fail with energy-efficient components (e.g. energy-efficient motors). In industry downtime can mean losing thousands of dollars per hour in forgone production. Such penalties may induce an understandable aversion to downtime and may cause many facility managers to shy away from new, unfamiliar technology that they fear might to be less reliable than the equipment they are used to.

3.10 Repair of Equipment

When a piece of equipment of a production line fails and has to be repaired (e.g. motor, pump, compressor) the concerns are the speed and price of repair, without concern to the efficiency of the job. A good example of possible problems is the repair of failed motors, where significant drops in the efficiency can occur.

4 Factors Governing the Operation of Industrial DSM Programmes

4.1 Measures and Instruments of Energy Policy

In order to promote the penetration of electricity efficiency, the most important types of measures are:

- Information and education
- Economic instruments (prices, taxation and financial incentives)
- Normative measures (labelling and standards)
- Research, development and demonstration.

These measures can be implemented by energy authorities, utilities, and by the manufacturers together with research laboratories. The energy authorities can have the responsibility in all the above measures, although their main role is in the definition of prices, taxation and normative

measures. Research laboratories and manufacturers (with the possible support from energy authorities) play a key role in research, development, demonstration and market development of new high-efficiency technologies.

In the absence of a strong demand for energy-efficient equipment by consumers, the most effective way to promote energy-efficient technologies is through programs that involve all the market players: utilities, trade allies, end-users, distributors, OEMs, etc. Financial incentives coupled with a suitable regulatory framework are a more effective way to promote efficient technologies than individual programs.

Utilities can also have a decisive role in removing the market and institutional barriers, which prevent the penetration of cost-effective high-efficiency equipment. In order to increase the penetration of conservation measures the utilities can use several methods, such as:

- Information and training
- Audits
- Zero or low interest loans
- Rebates
- Competitive bidding
- Direct installation by the utility

Some possible strategies, which can help to overcome those barriers and contribute to make efficient purchase decisions, are now examined.

4.2 Education and Training

More education on energy efficiency is needed on many fronts. Energy efficiency should be incorporated into engineering and technicians curricula. Junior engineers need one-on-one field training with experienced engineers and practicing professionals should have ready access to continuing education programs. Training consumers is a powerful way to raise their awareness with regard to the benefits of energy-efficient technologies. Training vendors so that they promote energy-efficient technologies by their own desire and encourage end users to trust in vendors' advice also yield market transformation.

Most end-users and many consulting engineers lack adequate information on the energy-efficient technology performance, economics and applications. The information supplied should typically cover the technologies which are widely used and have a large potential for savings (drivepower, lighting and process technologies) This information gap should be filled through several means:

Publications
Comprehensive publications relating to industrial systems efficiency, (including leaflets, brochures, handbooks and videos), should be issued and distributed by manufacturers, trade associations, electric utilities, government agencies, etc.

Databases
With the widespread use of personal computers, computerized databases represent another type of very important source of data to make optimized choices. Databases can be available as a diskette or CD-ROM. For example in North America the Motor Master data base is successfully being used by equipment designers and maintenance technicians to optimise

motor selection both in new and retrofit applications.

With the proliferation of information technologies (such as Internet), another potential to promote energy-efficient technologies emerge. Actions that will help to provide greater access to quality technical marketing and financial information are needed.

Seminars and Courses

Seminars that target engineering and maintenance staff are very important to promote energy-efficient technologies. But is also important that seminars will target managers too, because management must be committed if efficiency improvements are to be implemented. If there is some kind of inducement, technical and maintenance staff is likely to attend seminars.

Energy Audits

Several industrial audit programmes operated by utilities, regional energy offices, universities and ESCOS can provide detailed engineering analyses. This procedure could increase awareness of electricity consumption and foster future measures to improve the efficiency situation.

Carolina Power Administration (USA), for example, provided free detailed audits to its large industrial customers (peak demand greater than 1 MW). From 1983 to 1989, approximately 200 customers received audits, resulting in demand reduction of about 75 MW. Audits cover all energy using systems in a plant, including motors and other electric equipment. Audits were provided by six to eight full-time industrial engineers that work out of utility's central office. The utility has found that the best auditors were those who have worked as engineers within industry—they can best establish a rapport with industrial customers.

4.3   Provide Technical Assistance

Technical assistance programs fall into two categories: calculation aids, and on-site assessment and assistance.

Calculation Aids

Calculation aids are easy to use guidelines and design tools, which can be used in optimization, the choice of energy-efficient technologies. Due to its relevance, significant effort has been directed to motor systems. Motor systems are not properly optimized because those who make purchase decisions do not have the time or skills to do the necessary calculations. Calculation aids coupled with the motor databases address this problem with the use of reference tables, slide rules and computer programs. This aids to estimate costs and savings for a specific application based on limited amount of information gathered by the user, and to evaluate the economics of rewind versus replacement decisions.

Programmes to assist maintenance practices and to improve efficiency are also very important. Information on recurring maintenance tasks can be input into the computer, and work orders will be prepared by the computer according to a schedule set by the user.

Successful examples occurred in North America can be mentioned:

- Ontario Hydro (Canada) distributes to motor distributors and customers a free spreadsheet program that calculates the energy savings, demand savings, return on investment and simple payback of efficiency versus standard efficiency motors. User inputs are motor power, operating hours, efficiency and a peak coincidence factor.

British Columbia Hydro (B.C.Hydro) distributes a similar package.

- Electric Power Research Institute (EPRI) distributes two programs to assess the economic feasibility of retrofitting fan and pump motors with VSDs.
- Boneville Power Administration distributes a software tool (AIRMaster) to optimize the operation and maintenance of compressed air systems. With this tool an audit can systematically be carried out and the results analyzed, providing specific recommendations what to improve, how much it will cost and the associated payback time.

On-site Assessment and Assistance

The simplest of these programmes feature computerized audits furnished by utilities or government energy agencies. These audits often assess opportunities for using energy-efficient technologies. Technical assistance services that offer information and advice on efficiency improvements, without providing a full engineering audit are also a very important step.

Demonstration projects

One of the key factor that limit the adoption of energy-efficient technologies, is the strong scepticism about their viability. People doubt about their durability, performance and real savings. To overcome these difficulties, demonstration projects should be implemented, that effectively address market deficiencies, and generate technical information about the cost-effectiveness and performance of these technologies. Demonstration provides a forum between promoters and end-users that can give some feedback to promoters about end-users needs and wants. One successful example was the B. C. Hydro Power Smart Program which had a travelling "Energy Bus" which had motor demonstrations and was running a series of seminars energy-efficient technologies (B.C. Hydro 1992).

Procurement

This strategy aims to promote the appearance in the market of very high efficiency equipment with reasonable costs. A competition is promoted among manufacturers to produce the best equipment. The winning participant receives either a guarantee for a large purchase or is given a large prize ("Golden Carrot Incentives"). Procurement has successfully been applied in Europe and USA, for example to promote the introduction in the market of high efficiency refrigerators. The European Union has recently started a project to promote procurement of energy-efficient motors, whose outcome will be known in late 1998.

4.4   Prices

The tariffs are the most important tool to influence supply and demand. Behavioural studies show that most consumers will be influenced in the choice of high-efficiency equipment or will change their demand in response to price signals, although tariffs alone are not enough to ensure the penetration of high-efficiency equipment (IEA, 1989).

In many countries, particularly developing countries, the rates are based in historical average costs, which are normally lower than avoided costs. In order to achieve economic efficiency in selection and operation of end-use equipment, the rates should reflect the long-term marginal costs (both for energy and peak power) of the system, and prices should also reflect external costs. To ensure this purpose the regulatory authorities play an important role. Ideally, each customer should pay the respective costs in order to avoid cross-subsidization. The price structure should also be stable and be able to motivate the consumers to take the most cost-effective decisions.

Time-of-use rates (TOU) rates (both for peak demand and energy) have been used with most industrial consumers to differentiate the price of electricity during the day (e.g. peak, shoulder, off-peak) and during the year (e.g. winter and summer). Traditionally, these periods are predefined and consumers try not only to limit the peak demand but also to shift as much as possible the consumption to off-peak hours. A good example is the cement kilns where the milling of the limestone is carried out during off-peak hours.

All categories of consumers deserve equal treatment and economic efficiency in the tariffs. Especially important is to differentiate the price of electricity to consumers, which require different levels of reliability. Reliability is a variable increasingly considered being determined by economic considerations rather than by engineering standards. Modern communication, control and metering technologies can be used for price-reliability differentiation to decrease peak demand and to save valuable reserve margin.

Interruptive rates allow utilities to give preferential rates to consumers who are willing to shed part of their load (typically during peak demand periods), when requested by the utility. Many industrial consumers, who can switch-off non-essential loads without little or no loss to the production, are benefiting from these types of contracts, which allow utilities to reduce peak demand by a few per cent. A typical example may be a metal industry, which receives a request 24 hours in advance to switch off a fraction of its load (e.g. a furnace).

4.5   Taxation

By influencing prices, taxes are also a powerful tool to direct the market forces in the desired direction. Electricity is taxed in all countries, but in general it receives a more favourable treatment than other forms of energy, especially in comparison with oil products. The main purpose of the tax has been to raise revenue for financial reasons, but taxes may also be used to reflect social costs such as:

- Environmental impacts, such as global warming, acid rain, health effects, etc.
- Depletion of non-renewable resources
- Economic impacts (e.g. energy security, balance of trade)

A program to be taken into account when legislating about energy taxation may be that of the Danish Government: the Energy 21 plan (Danish Energy Agency, 1995). In fact, this package of laws aims two main goals: to decrease significantly the level of pollutant emissions (20% of CO_2; 80% of SO2 and 30% of Nox) by the year 2005 and to promote independence in relation to fossil fuels. So, in order to achieve these goals, a substantial taxation package has been approved, mainly consisting on:

Table 2. The New Danish Energy Tax System

Heavy processes:	A CO$_2$ tax of DKK 5 per ton of CO$_2$ in 1996 to be stepped up gradually to DKK 25 per ton of CO$_2$ in 2000. Reimbursements are negotiable, effectively reducing the tax rate to DKK 3, provided enterprises accept to implement an energy-saving action plan.
Light processes:	The current CO$_2$ tax to be stepped up gradually from DKK 50 in 1996 to DKK 90 per ton of CO$_2$ in 2000. Enterprises with a high level of energy consumption can opt for an agreement obliging them to undertake an energy-saving action plan, even though the relevant production process is not considered to be heavy. In this event the enterprise will receive a reimbursement.
Space heating:	Energy and CO$_2$ taxes to be stepped up gradually to the same level of taxation as applies to households, i.e. an average level of approx. DKK 600 per ton of CO$_2$.
A tax is to be introduced gradually on all energy consumption at a rate of DKK 10 per kg SO$_2$ with special reimbursement schemes for the consumption of coal and fuel oil for certain enterprises.	

Furthermore, this program foresees not only the reimbursement of the enterprises which agree to invest in energy-efficient programs but also a full tax liability to those who decide not to do so. Another possible strategy, an universal energy tax, introduced unilaterally and without compensatory measures, would be detrimental to the competitiveness of a huge number of enterprises, increasing unemployment unacceptable. To avoid this, it has been decided that all the revenue raised by the energy tax should be recycled to industry and that the rates of taxation shall be differentiated according to the level of energy consumption in the various production processes.

4.6 Financial Incentives

Customers will typically only implement measures with two-three years payback or less. Financial incentives are elaborated to overcome financial barriers (namely the payback gap and the capital availability gap) to energy-efficient technologies adoption and may represent one of the most cost effective way to promote (Pye, 1997).The most common financial incentives are described bellow:

Prescriptive Rebates. Rebate programmes directed at prescriptive measures (such as energy-efficient motors and variable speed drives) have been widely applied by utilities. The most popular type of rebate in North America has been directed to promote energy-efficient motors.

Generic Rebates. Generic rebates reward customers for savings achieved through measures of the customers' choosing. They generally take one of the following forms:

- payments per kW or kWh saved (either in the first year or over the measure life time)
- payments as a percent of measure cost
- payments to bring the simple payback for a measure down to a specific level

Direct Incentives to Distributors. Distributors of end-use equipment are well placed to understand consumer needs and wants. Perhaps the best way to involve distributors in utility programs is to give them financial incentives (e.g. B.C. Hydro's 1992 program for energy-efficient motors offered rebates of US $293/kW saved to customers and $59/KW saved to

distributors (B.C. Hydro 1992).

Loans. Loans can compensate the limited access to capital that can prevent many customers from investing in efficiency. Subsidized loans with zero or low interest rates are particularly attractive to customers.

Leasing. Leasing specific pieces of energy-saving equipment also obviates searching for investment capital.

New Installation Incentives. New installations are golden opportunities to use efficient technologies. To incorporate efficiency measures when a facility is built is much less expensive than retrofitting them later, because the extra capital, design, and installation costs are much lower for new installations.

Bidding. Under bidding programs, utilities request proposals from outside parties to supply demand-side and supply-side resources. Bids are selected on the basis of price, and other factors. One purpose of bidding programs is to allow the marketplace to determine the price of savings. Bidding programs must address the following issues:

- bid evaluation criteria
- the resources to be solicited and sectors to be targeted
- bid ceiling prices
- mechanisms for measuring the savings.

Bidding is likely to contribute most significantly to savings in the large commercial and industrial sectors.

4.7 Labelling

Labelling helps to bridge the information gap of consumers about equipment performance and increases competition among manufacturers to raise the efficiency of the equipment. Labelling can help consumers make informed choices about equipment efficiency. Labelling should also help consumers to compare relative performance against models from other manufacturers.

To be effective labelling should state the equipment efficiency, the operating costs under typical operating conditions (e.g. number of operating hours, electricity prices) and preferably, the relative performance of the equipment compared to models from other manufacturers. Labelling increases competition between the different manufacturers to improve the efficiency, especially if it provides comparative performance among manufacturers.

4.8 Voluntary Agreements

This strategy involves agreements between manufacturers, trade associations and regulatory authorities, to establish minimum efficiency energy levels that meet the desired performance level of contenders. On the end-use side, a similar effect can be reached by Bench-Marking-Systems of Associations. These systems allow comparison of the relative ranking in regards to energy/ electricity use in comparison to other companies etc. The results of energy audits can be used for this purpose.

One successful example of voluntary agreements is the Energy Star Programme applied to

personal computers, monitors and printers.

4.9   Efficiency Standards

An important market transformation tool arrives through the establishment of minimum efficiency standards. Efficiency standards go a step further than labelling by defining minimum efficiency levels of new equipment. Equipment efficiency standards can achieve savings beyond those achieved by utility programs.

Besides removing inefficient equipment from the market, standards also stimulate innovation and competition among manufacturers. The setting of efficiency standards should be based on realistic and cost-effective goals, defined in cooperation with manufacturers and research laboratories. Standards also prevent low-efficiency and low price imports from entering the market. Standards define minimum efficiency levels and help to overcome the following barriers:

- lack of information of energy performance
- market inertia to introduce high efficiency equipment
- split incentives barrier
- energy costs have little influence on the buyer's decision
- remove inefficient equipment from market

In the case of motors, this measure has been already adopted with success in the British Columbia, Canada in January 1995, and it was extended to other Canadian provinces in January 1996. In the US, it will be enforced in October 1997, through the Energy Policy Act– EPAct, mandated in October 1992. Table 3 shows the minimum nominal full-load efficiency of electric motors* mandate by EPAct:

Table 3. Minimum Nominal Full-Load Efficiency of Electric Motors

Motor Horsepower	Efficiency (%)
1	82.5
5	87.5
10	89.5
25	92.4
50	93.0
100	94.5
200	95.0

* - 4-Pole Closed Motors, TEFC

These standards will particularly be effective for OEMs, obliging them to incorporate EEMs in their equipment. These standards recommend or require motors to exceed specific efficiency levels, which vary with motor size, motor speed and enclosure type.

4.10   Use of Combined Strategies

All the identified strategies can produce the motor market transformation, but while enforced regulation and financial incentives (e.g.: tax incentives for those companies who buy energy-

efficient motors) will guarantee a large scale penetration of EEMs, educational programs alone will produce marginal changes.

A combination of strategies may be used to transform the motor market. An outstanding example of motor market transformation has occurred in Canada in the service territory of British Columbia Hydro (see Figure 1). B.C. Hydro's program of education and financial incentive increased the market share of efficient motors from 3% to 60% in a period of three years. The utility is now supporting legislated efficiency standards to sustain the market, and will ramp down the program as market forces and standards take effect.

B.C. Hydro's Influence on the Motor Market
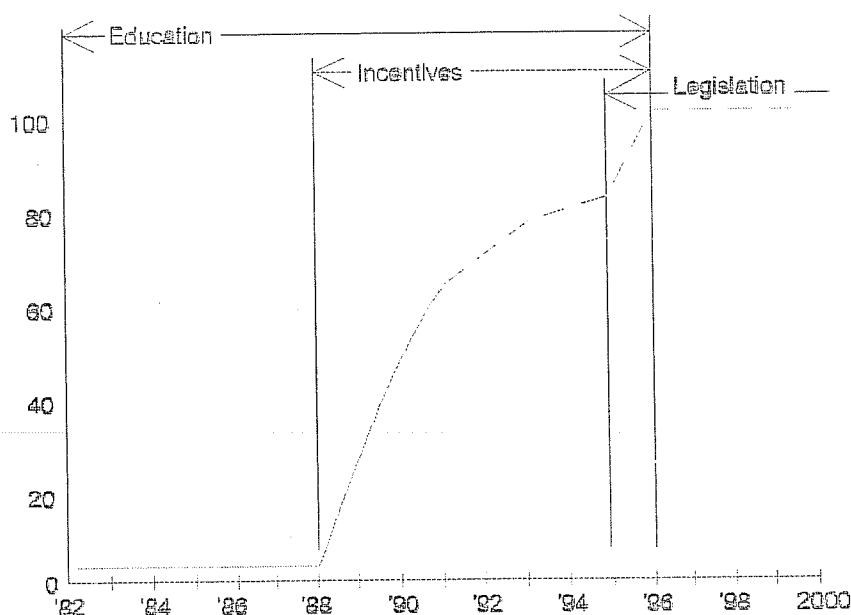
Figure 1. Example of Successful Market Transformation (B.C. Hydro 1992)

5   Industrial DSM Programmes in Developing Countries

Developing countries are generally characterized by a fast growth of the electricity consumption, which in some cases approaches or even surpasses 10%/year. This level of growth has required a huge investment effort to increase the required generation, transmission and distribution capacity, in order to meet the demand. In many cases there have been capacity shortfalls leading to periodic power outages, which interfere in a negative way with the economic activities and mitigate the possible economic growth. Additionally the capital resources required for the expansion of the electrical pow.. system compete for scarce capital resources, which can be applied in other essential infrastructures in fields such as education, health, transport and telecommunication.

The above factors make electricity conservation activities very pertinent in developing countries, because although the per capita consumption is quite modest, the potential for cost-effective electricity savings is substantial (Geller, 1997 and Miller, 1992). Since the industrial sector typically represents over 50% of the electricity consumption of developing countries, the rewards for effective industrial DSM programs are quite large. Although several

developing countries (such as Brazil, Chile and Thailand), have already started a significant effort to promote electricity conservation, the savings potential remain essentially untapped.

Brazil is probably the best example of a country where there has been a sustained effort for electricity conservation (Geller 1997). A national electricity conservation program PROCEL was created in late 1985, which has received funding of about US$10 million/year. More recently in 1995 and 1996 there was a substantial increase in the funding available for energy efficiency projects. The PROCEL program is financed by the holding Electrobras, which generates most of the power, and the expenses are recovered through the rates. The electricity savings achieved (2.4 TWh) are close to 1% of the electricity consumed in Brazil in 1996 (265 TWh), but due to the increased level DSM effort the achieved savings have accelerated reaching 0.8 TWh in 1996 (about 50% of present consumption).

These savings have been achieved in a very cost-effective way. Assuming an average marginal cost of US$2000/kW of installed generation, transmission and distribution capacity, the conservation programs carried out since 1986 saved supply-side investments in the order of $1.6 billion for a total expenditure in the program of $115 million. These figures translate into an impressive benefit-cost ratio of 14:1. Electrobras plans a significant increase in the electricity savings, to reach the value of 130 TWh by 2015.

Although most of the effort has been directed to the residential and commercial sectors, the industrial sector was also a target for DSM activities. These activities included consumer education and training, audits, promotion of efficient technologies and ESCO support. Two end-uses have received special attention: lighting and drivepower. High-pressure sodium lamps have been promoted in industry mainly through energy audits and seminars.

Since basically all motors sold in Brazil are locally manufactured, PROCEL collaborated with local manufacturers to improve the efficiency of the motors, to define an efficiency testing and labelling for 3-phase induction motors and to define a norm stating mandatory minimum efficiency levels for high-efficiency motors. Giving awards to the manufacturers of the most efficient motors increased competition between manufacturers to improve motor efficiency. The sales of energy-efficient motors only represent 1% of the sales in 1996, although the sales doubled in relation to 1995.

The growing success of PROCEL is due to a combination of factors including:

- Implemented and lead by Brazilians
- Maturity achieved over a period of more than ten years
- Economic stability and higher electricity prices
- Involvement of relevant stakeholders (utilities, manufacturers, ESCOs, industry associations, state agencies, municipalities, researchers)
- Promotion of capacity building to develop and implement electricity conservation by utilities and the private sector.
- Availability of low-cost financing

6 Conclusions: Main Factors for Successful DSM Programmes

Industrial DSM programmes are being applied around the world with a variable degree of success. Past experience has shown that successful programmes are focused on the customer needs and use a combination of mechanisms (Nadel, 1990) not only to ensure the large scale penetration of the DSM measures, but also to ensure that the installed measures are cost-effective (Figure 2). Some of the most relevant factors appear to be:

- Information and Technical Assistance to help the target customers to identify the cost-effective saving opportunities, and to implement the selected measures.
- Marketing, using multiple approaches but emphasizing personal contacts to build a close relationship between the customer and the utility.
- Targeting the DSM programs to the specific customer needs and to the type of audience
- Simple Procedures and Materials, in order to allow easy understanding of the programs by the customers, who normally are very busy. In the cases in which some part of the program has some complexity assistance should be provided.
- Financial Incentives to call customer attention and to decrease the initial cost and payback time of the DSM investments.
- Involvement of Trade Allies, in order to allow proper design and installation, as well as product availability.
- Energy Service Companies can also play an important role by providing the expertise to identify and install suitable measures, as well as the capital for the DSM investments, which is recovered through the reduction in the energy bills
- Multiple Measures, which allow the customers to select the most appropriate measures for their business, provided they are cost-effective
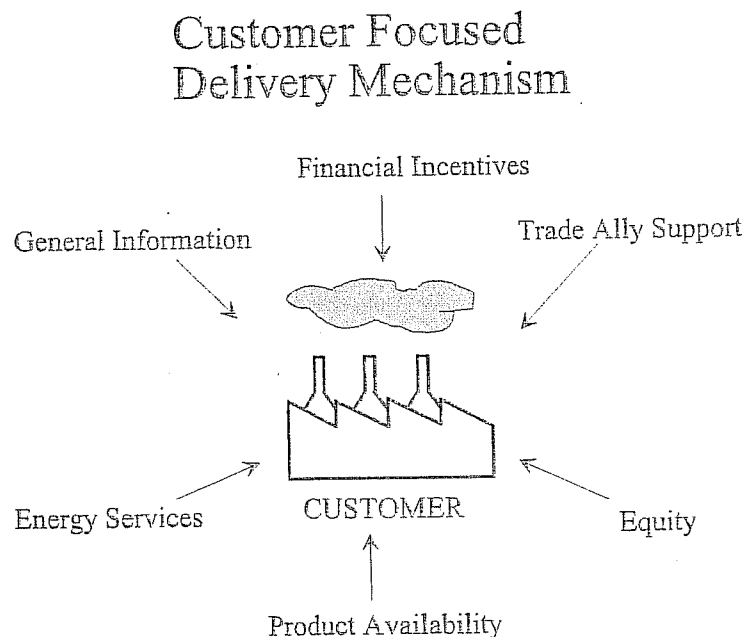
Figure 2. Combination of mechanisms for successful DSM programmes

7 References

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Successful Implementation of Energy Efficiency in Light Industry:

A Socio-economic Approach to Industrial Energy Policies

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1 Industrial Energy Efficiency: A classic still on top of the political agenda

For more than two decades, questions of how to increase energy efficiency in industry have been on top of the energy political agenda. And still, it is an issue of relevance for energy politics and industrial economics. With respect to the manifold and severe environmental damages, which are threatening the stability of regional up to global eco-systems, a dramatic decrease in energy and resource consumption in industrialized countries will be inevitable[1]. Among the most pressing problems, global climate change calls for a significant reduction of CO_2 emissions and a major contribution can be expected from strategies to improve energy efficiency (Enquete, 1995).

With regard to this challenge, the implementation of cost-effective energy efficiency measures represents an attractive means to join ecological and economic goals (Commission, 1998). Multiple analyses[2], however, indicate that considerable profitable energy conservation potentials are not yet sufficiently exploited although suitable technologies are freely available on the market and dozens of energy programmes have been launched in the past. Manifold empirical evidence support the assumption of an "implementation gap" which cannot be satisfyingly explained by a lack of appropriate technical solutions—so the same questions still guide today's industrial energy policy:

- What triggers the implementation of energy efficiency measures in industry?
- How can energy policy influence the adoption of clean and energy-efficient technical and organisational solutions?

In this context, this paper aims to contribute to an increased knowledge about energy-saving activities in the—often insufficiently analysed—target group of SME from less energy intensive sectors. It is the objective to point at crucial features of successful realisation of energy-saving projects in firms and, thus, to indicate opportunities for policy-makers and energy efficiency market actors to stimulate and to foster the implementation of new energy efficiency measures, and to increase the related demand for energy services. The empirical basis focuses on SME; however, there is some evidence that the general findings and policy implications can contribute to the discussion of appropriate policies for larger firms, too (TTI 1998). With regard to the design, management and evaluation of energy policy initiatives for industry, the paper tries to answer the following questions:

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[1] Sachs, Loske, Linz et al. 1998, Weizäcker, Lovins, Lovins, 1997
[2] cf. Bradke et al. 1996, Enquete 1995, Wuppertal Institut/Öko-Institut 1995, 1997, de Beer et al. 1994

- What are the deficiencies of the current discussion on industrial energy efficiency (2)?
- What are the characteristic features of successful energy conservation activities in SME as the target area for policy intervention (3)
- What conclusions can be drawn concerning an overall policy philosophy (4) and a segmentation of target groups (5)?
- What can be learned regarding the design and management of policy programmes (6 and 7)?

2   Does the Traditional Debate on Industrial Energy Policy Miss the Point?

On the European level, these questions are closely connected to the recent liberalization of the European energy markets for electricity and gas (Commission, 1996). From de-regulation, a growing competition among the suppliers of final energy (electric and gas utilities, independent power producers, industrial auto-production, etc.) can be expected, which promises a decline in industrial energy prices. However, from a macro-economic perspective on energy systems, the crucial question remains, whether liberalization with its current features will only squeeze energy end use prices or actually contribute to overall macro-economic efficiency of the energy system. As a basic condition to achieve the second, the overall costs of the energy system have to be minimized, i.e. energy markets have to ensure that all cost-effective energy efficiency potentials will be implemented until the marginal costs of conserved energy equalize the marginal costs of supplied energy.

With respect to the latter requirement of overall economic efficiency, the notion of functioning energy markets has been intensively debated in the past. Especially the nature and impact of market failures and barriers to the rational use of energy have been subject to controversial discussions[3]. The discussion can be roughly characterised by two contrasting positions—"traditional market optimists" versus "energy policy optimists"—that reflect two different views on the implementation of energy efficiency in industry. Although contradictory in many aspects, both perspectives tend to argue within the limits of a comparable mechanical and technocratic understanding of the adoption of energy technologies by industry and a resulting simplistic view on the functioning of "energy markets" (see Figure 1).

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[3] See for example the debate of Sutherland 1994, 1996 and Sanstad, Howarth 1994, Sanstad, Koomey, Levine 1994.
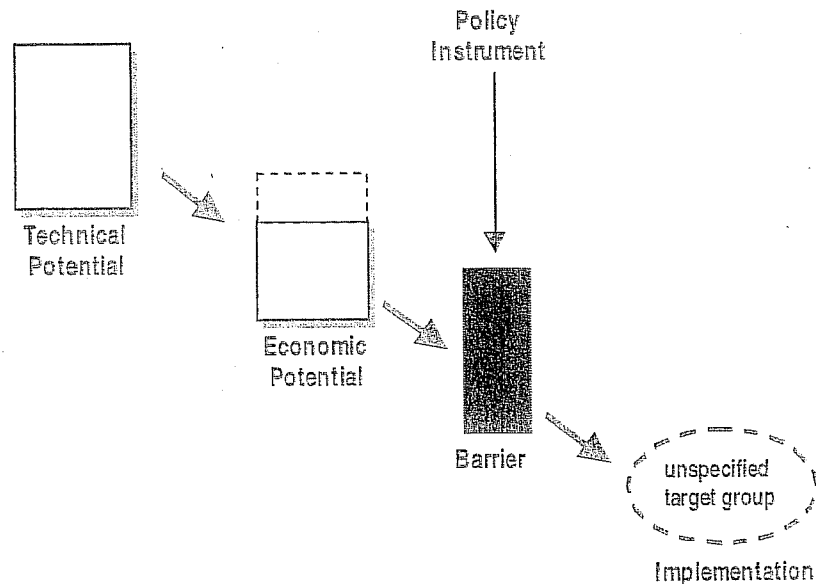
Figure 1. Linear and static understanding of barrier policies

Firms are perceived as pure micro-economic entities, and the focus of the corresponding political debate is primarily put on the questions, (1) whether the economic decision of the energy consumer (e.g. firm) is hindered by obstacles or not, (2) whether these barriers justify top-down political intervention by a public agent, and (3) what political means are appropriate and theoretically sound in terms of economic efficiency. As a result of the theory ridden economic bias of the debate, the necessary discussion about appropriate and effective CO_2 abatement strategies is often reduced to a simplistic categorisation and confrontation of general concepts ("command and control" versus "market orientated"). The exclusive discussion of isolated instruments—in the light of the Kyoto negotiations now mainly concentrating on taxes versus tradeable permits[4]—ignores decisive features of industrial energy use, interdependencies and side-effects between parameters and actors involved in energy efficiency measures as well as the dynamic nature of market processes. Two major shortcomings concerning the energy political focus and the perception of the industrial target group can be identified as the following:

Simplification of the Economic Decision Problem

In traditional economic analyses, the industrial energy efficiency problem is reduced to a debate on energy efficiency investment decisions. The take-up of advanced energy technology is seen as an economic optimisation problem on the base of marginal costs of energy supply and conservation techniques[5]. But companies are not interested in energy in and of itself. What they need for their production purposes are energy related functions such as well tempered rooms, cooled storages, moved semi-products, lightened work places, communication, etc. (see Figure 2). Final energy carriers such as electricity or gas are purchased in order to be transformed within the firm's energy system (heaters, compressors, light bulbs, etc.) into

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[4] See for example the discussions on the 1st Symposium of Shared Analysis (1998)

[5] The same holds for concepts of energy conservation supply curves or Integrated Resource Planning which are based on the marginal costs of conservation technologies, too. Theoretically, other costs such as hidden costs, transaction costs etc. could be integrated but are rarely operationalized nor quantified.

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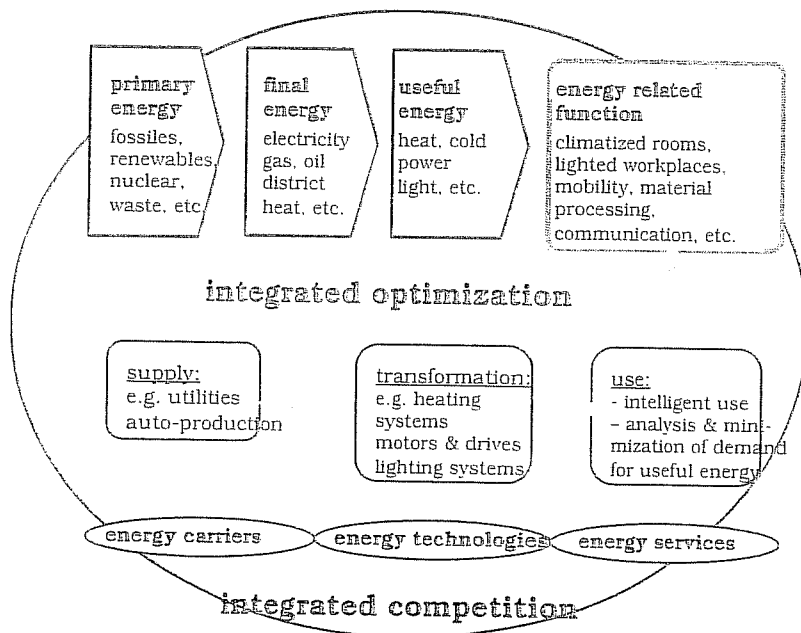useful energy which serves the demand for energy related functions.

Figure 2. Integrated optimization of industrial energy systems

In this holistic perspective, the minimization of the firm's total costs to serve their demand for energy related functions requires an **integrated optimization** of the whole energy system. This includes all transformation steps in the sense of an intelligent use of adequately dimensionized, highly efficient components, which are properly run and maintained, together with the choice of cheap energy suppliers. The company has to solve a multi-dimensional optimization problem concerning the optimal mix of energy technologies, energy services (such as auditing, planning, financing. operation & maintenance, consumption monitoring & management, training & qualification etc.) and energy inputs (electricity, gas, oil etc.).

It is evident, that in this context any discussion on industrial competitiveness concentrating exclusively on the level of energy prices has to fall short. With the objective of low energy bills in industry (rather than low energy prices), energy policy has to put emphasis on conditions and factors which help the enterprises to perform their integrated optimisation task. This includes questions of whether an appropriate offer and functioning markets for combined energy technologies and services already exist. With these supply-side aspects of energy service in mind, however, this paper will concentrate on decisive determinants for the energy service demand, i.e. the internal conditions for initiating and performing energy efficiency projects in SME. In this respect, the human factor gains additional importance, e.g. in terms of internal workforce and know-how, management capacities for integrated energy projects, and communication and cooperation with external consultants, suppliers etc.

Starting from this premise, the focus of energy research has to be shifted from a narrow and rather ideal-type perspective on economic calculations of energy technology investments to a broader and dynamic socio-economic analysis of energy efficiency activities under real world conditions, following the research questions:

- What decisive influence factors determine the behaviour of industrial actors in the various sub-markets (energy carriers, technologies, services) and what triggers the development of energy efficiency activities?

- How are economic decisions of the firm embedded in socio-economic and organisational processes and what is their importance for energy policy-making?

Economic Perception of Industry as a Homogeneous Target Group

Looking through economic energy research, analyses often refer to "industry" as the research issue—but what is "industry"? For example, contrasting large energy consumers such as a chemical plant with small metal manufactures, it is evident that energy related technical, organisational and economic factors differ significantly (Gruber, Brand, 1991, Pfohl et al., 1997). Furthermore, aiming to cover major shares of industrial energy consumption, most analyses tend to focus on energy intensive sectors such as chemical industry, steel industry, paper and pulp, etc. As a consequence, less energy intensive sectors (e.g. investment and consumer goods), which are characterized by small and medium enterprises (SME), are systematically neglected, although in total they can represent a considerable share of industrial energy consumption.

Additionally, SME are of remarkable economic importance, which has been increasingly acknowledged by politics e.g. within the design of the 5th Framework Programme for Research of the European Commission (1997). For example, in the year 1996 99,6 % of all German enterprises counted less than 500 employees. These firms contributed to 47 % of taxable turnover and 68% of all jobs, and contributed equally to 45 % of gross added value and gross investments (BMWi, 1997). In addition, many regions are characterized by an industrial SME structure, emphasising the importance of this target group for regional economics as well as for the local and regional utilities, which have to address this specific target group in times of competitive energy markets (Ramesohl, Schwarze, 1998).

With respect to the mentioned deficiencies of the prevailing "mainstream" of barrier and energy market failure discussion, the paper wants to contribute to a more differentiated understanding of industrial energy conservation activity and to point at an emerging scope for energy policy-making. It presents a new interdisciplinary, dynamic and cyclic perspective for energy and climate policy, derived from in-depth qualitative socio-economic analyses of successful activities in the field of energy efficiency in small and medium-sized enterprises (SME) (InterSEE, 1998). The study's empirical foundation comprises 31 in-depth case studies of SME from 11 sectors as well as 15 policy programmes and initiatives dedicated to this target group.

The underlying research agenda is seen as a contribution to a new and broader understanding of the economics of energy efficiency implementation[6]. Hence, the bottom-up orientated strategy for an interdisciplinary research of change and innovation in industry represents an useful and indispensable complement of top-down orientated macro-economic analyses, which investigate the overall techno-economical consistency of policy mixes. In combination, both approaches will open new perspectives and possibilities for synergies improving the quality of scientific support to energy policy-making (Scheraga, 1994).

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[6] The need for corresponding research was expressed e.g. by Huntington 1994, Koomey, Sanstad 1994.

The core result of the analysis can be described as a shift of perspective from the energy related decision making to the underlying process of decision preparation and implementation. While traditional analyses tend to put the focus on the timeless moment of energy efficiency investment decision—which is taken by a rather impersonal decision-maker—priority is now given to the time period from the first impulse to the final conclusion of an energy efficiency project. Here, the interaction of various actors inside and outside the firm over longer time and the impact of external factors gain importance. The implementation process can be roughly structured by the four phases: Initiation and first impulse, Preparation and Decision, Realisation, Evaluation and Continuity (Figure 3).
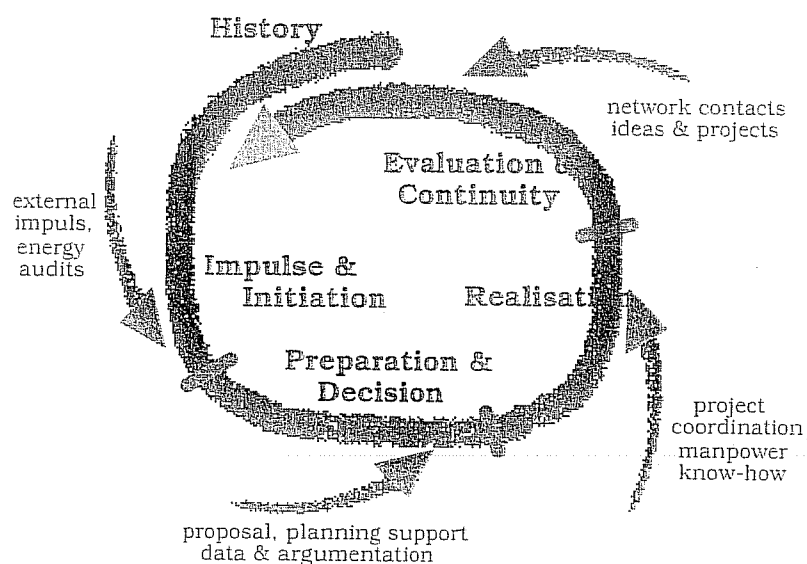
Figure 3. The four phases of the energy efficiency project implementation process

Figure 3 presents an overview of the four sections of the implementation process in a circle—or rather spiral-like form—of individual and organisational activity. Successful energy efficiency projects change the status of internal company interaction, e.g. by positive experiences with unfamiliar technologies, and thus can induce follow-up projects. In this respect, stage at the same time the last stage represents the first stage for further activities. For example, a new RUE project will benefit from altered organisational conditions or better data on energy consumption, and the process represents one *internal company learning loop* in relation to energy efficiency projects.

3.1   Initiation and First Impulse: Which pre-conditions foster energy efficiency measures in SME and what are major triggering impulses?

In the first stage, the existing company culture serves as the general, historically developed background that strongly influences the perception of energy issues and thus the chances to create a general motivation to become active in energy efficiency. It can hardly be altered in the short term, which emphasises the importance of long-term learning processes (see 4.4). Within this given context, first impulses stimulate an internal actor to think about energy efficiency and to initiate the planning, decision and implementation process. As depicted in Figure 4, it has to be distinguished between:

Internal stimuli: Action with impact on energy efficiency can be pushed by business-related problems (breakdowns, insufficient product quality, growing competition, scarcity of resources etc.) and opportunities (re-investment, new personnel, change of ownership, move to new location etc.). These factors can hardly be directly influenced by energy policy but have to be used as occasions for policy intervention.

External stimuli: There are energy-related means of pressure (regulation, price increases etc.), incentives (subsidies, funds, awards, support etc.) and positive examples (information, best practice cases etc.). Here, energy policy can give direct impulses.
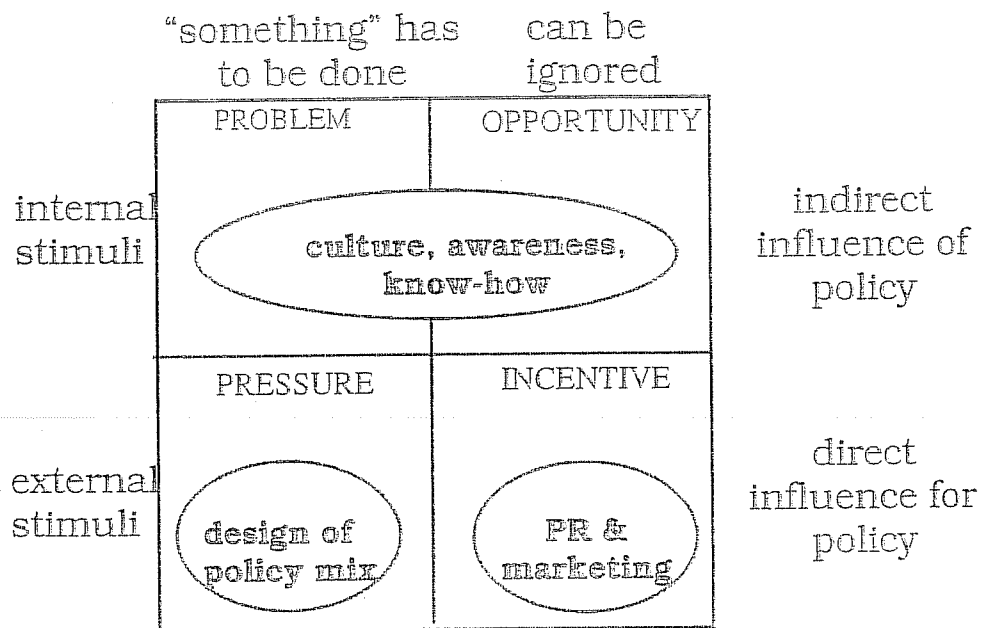
Figure 4. Structure of triggering impulses for energy efficiency measures

As the core result concerning the start phase of a RUE project, it has to be stated that external actors play the decisive role in bringing the issue on the agenda, which emphasises the need for an active energy policy. Engaged external partners (such as consultants, associations, utilities etc.) transmit and amplify policy and market signals and elaborate opportunities for RUE action in SME. These external links are often characterised by personal and trustful relations, lasting during the whole process and even longer. If regular external exchanges of experiences with other companies exist, meetings or workshops serve as a chance to communicate the benefits of energy efficiency as a cross-sectional issue.

3.2 Preparation and Decision of an Energy Efficiency Project: How does it come to a positive decision and action?

For most SME the implementation of energy efficiency represents an innovation in the sense that it produces new patterns of behaviour inside the company. This new way of perceiving energy and using energy-efficient technology can be "new" in relation to the history of the specific company (unfamiliar terrain) and in relation to other companies (front-runner of the branch or region). Thus, an innovation can take place even if "low technology" is implemented and this technology represents state of the art to other firms, regions or sectors. With regard to multiple hurdles connected to innovation in general, a basic condition for innovation in energy efficiency is that one or more motivated key actors inside the company continue to act as a multipliers and promotors of the idea. Internal key actors have to:

- contribute to the development of concrete concepts for the project (e.g. in interaction with other internal or external company actors)
- use or foster positive personnel relations (e.g. by a staff-orientated style of leadership)
- establish an internal coordination structure for the project (workgroups, schedules).

As a crucial step towards success, the key actors have to achieve the commitment of top-management. In most cases, energy has minor economic importance and is not a topic per se for the SME executives. Therefore, RUE measures have to be promoted by a broad mix of motives and arguments. The economic viability of a project can be supported by anticipated improvements in product quality, better working conditions, and image gains. In this phase, insecurity and reluctance has to be overcome by clear, pragmatic and convincing proposals for action. Interestingly, many cases energy efficiency is part of a broader environmental concern while a distinct identification with energy and climate issues is missing. This observation indicates the need for a stronger integration of energy and environmental policies within a general concept of eco-efficiency, e.g. in line with EMAS or ISO 14000ff.

In addition, the initiation of RUE measures requires that the relevant actors perceive enough self-efficacy[7], i.e. they think that 'it can be done'. Internal company actors need to perceive that they have sufficient resources and know-how to cope with the challenges brought about by the projects, and that they will be able either to avoid or to overcome possible difficulties and inconveniences in the course of implementation. Factors strongly influencing the feeling of self-efficacy are: financial and especially time resources inside the company, support by top-management for key actors on lower levels, energy related know-how, experiences with energy efficiency and the availability of data (key figures) on energy consumption inside the company. External actors play an important role to foster the internal company decision process by:

- indicating concrete options for RUE measures (know what to do) and energy related competence (know-how to do)
- providing information to legitimise the proposed projects inside the company
- external back up, e.g. for the calculation of profitability, for the investigation of possibilities of government subsidies, for the provision of an overview on energy consumption and for technical or organisational recommendations.

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[7] cf. the concept of *self efficacy* (Bandura, 1977a) and the theory of planned behavior (Aijzen & Fishbein 1980; Ajzen 1991).

3.3 Realisation: What is needed for a successful realisation of energy efficiency measures?

In the early stages of the realisation of an energy efficiency project, the development of a stepwise implementation plan with concrete (interim) targets and the documentation of (interim) goals and realisation schedules helps to manage and to monitor the process. A testing phase or an internal demonstration project reduces the perceived risk and increases the feeling of self-efficacy.

The energy efficiency project is fostered by related organisational changes (decentralisation of responsibilities, project teams) which improves the use of internal resources, experiences and know-how. During the realisation phase, the project should become an issue for the whole company, which requires internal communication and convincing feedback of success (in internal newsletters, meetings, etc.). Based on a detailed monitoring of activities by installing meters, measurements and controlling of consumption, the feedback of a positive development contributes to an increased motivation to continue. Furthermore, at this stage the active involvement of staff is an important possibility of fostering the internal learning process and the internal diffusion of efficiency activities.

External actors help to coordinate the activities of the different actors involved and to transfer know-how inside the companies.

3.4 Evaluation and Continuity: What makes the energy efficiency process go on and what contributes to the dissemination of positive experiences?

If the different actors involved enforce each other, the last stage can represent the first stage for further activities. In this case the company enters into a new learning circle and a long-term success is in sight (the learning company). Based on the positive results reached in previous (energy efficiency) projects, companies then tend to strive for excellence in energy efficiency and it becomes more likely, that they open up new fields in the general area of environmental protection (evolution of a green business culture).

The extension of energy efficiency related contacts in the course of the implementation is an important fostering factor for the continuation of activities. Three levels of interaction with external actors stabilise the process and encourage internal company actors to keep energy efficiency on the agenda:

1. the process of modelling and diffusion: informal and personal face-to-face contacts between representatives of different companies work as a very important channel of diffusion. By communication of its own positive experiences and the detailed demonstration of practical examples, the company serves as a convincing model for other companies.

2. a fostering exchange with the company's stakeholders: the company is a centre of a network of external relationships to suppliers, customers, authorities, etc., that fosters the energy efficiency activities inside the firm and at the partner's side.

3. the networking of companies: Each company—as a 'knot' in an energy efficiency related network—serves at the same time as sender, as recipient and/or as multiplier of energy efficiency related information.

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4   General Policy Implications and the Need for Policy Mixes

Although there is evidence that a wide range of cost-effective energy efficiency potentials exist, it has to be stated that a large scale implementation of these profitable RUE measures in the SME target group is not automatically enforced by existing markets. Energy conservation projects don't follow the classic approach "technical potential—economic profitability—implementation". Accordingly it is helpful, but not sufficient by far, to launch policy instruments aiming to increase economic profitability of energy efficiency projects. This view is supported by the fact that in the case of the success stories, financial incentives have been only one fostering factor among others (often not the most important). With respect to the manifold and interdependent influence factors found, stand-alone financial instruments in terms of subsidies and grants seem to be less appropriate for use as a direct lever to initiate and influence energy efficiency activity in SME.

The empirical findings rather suggest a variety of inducing and fostering factors, which have to be combined in order to trigger and maintain implementation processes. As a main result, it can be stated, that a single intervention such as only an information package or a financial offer or the appointment of an energy delegate is likely to remain insufficient. However, the combination and enforcement of various impulses, instruments and policy measures promises the creation of long-term momentum and the evolution of an energy efficiency infrastructure. This might result in sophisticated energy and eco-management systems, fueled by a lively green company culture.

The previous consideration points out that to a great extent innovative energy policy can be seen as a communicative, organisational and cooperative challenge rather than being solely a question of prices, investment subsidies and grants. With respect to the identified multitude of different fostering factors, energy policy-making has to elaborate suitable policy mixes, combining various and different policy instruments in order to provide incentives and support during the whole implementation process. Starting an energy efficiency project requires a socio-economic setting, which—apart from a limited number of front runners—is rarely given among SME under the current situation. In this regard, empirical evidence from the case studies supports the need for an active role of energy policy in providing the necessary motivational, communicative and cooperative background. Supported by other socio-economic studies on larger companies and more energy-intensive sectors (TTI, 1998), three domains for energy policy engagement can be derived:

- Energy efficiency has to become a topic on the company's management agenda. Due to the low priority of the issue and the hindering effects of existing daily business routines of treating (or rather neglecting) the topic energy projects, distinct marketing and mobilisation efforts are needed, which includes the involvement of suitable multiplicators and the set-up of target group specific communication strategies.

- To reach a lasting change, energy efficiency has to develop gradually from an innovation to a routine practice. Individual measures of RUE cannot be seen as separate from everyday company activities but have to be integrated into a process-orientated strategy of company development and learning. In order to support the learning company in terms of energy efficiency, policy intervention should establish an array of subsequent learning circles, based on the creation of organisational infrastructures for energy efficiency and feedback of positive experiences.

e Reflecting the paramount role of external actors for the realisation of RUE measures and effective implementation of policy programmes, the links of company actors to external partners have to be strengthened through energy efficiency-related cooperation, e.g. by networks. The empirical findings indicate that an increased demand for energy-efficient technologies and services can be expected through dissemination of best practice and positive experience, and by development and diffusion of professional energy efficiency know-how e.g. in work groups (network formation).

5   There Is No "Golden Way": Relations between types of companies and selected policy instruments

The illustrated need for multidimensional policy mixes, however, cannot be satisfied by a general "golden way" kind of solution. Within the general line of successful implementation processes, the investigation in the structural characteristics has shown a typology of successful implementation processes of RUE measures in SME. The different company culture and the corresponding types of success indicate that there is no exclusive and optimal way to a successful realisation of energy-efficiency measures. Firms are characterised by one or several areas of particular strength—and if an appropriate environment e.g. by cooperation is given, the case studies suggest that one area of strength can be sufficient to reach success. Hence, industry and even the sub-group of SME cannot be treated as a homogeneous target group. From the empirical material, four different types of (successful) companies were derived and change dynamics related to the type of success appear to be very limited. The 'company types' developed over time and seem not to be easily altered by management or outsiders in a short-term perspective. Consequently, policy will not be able to design a suitable "one-size-for-all" programme, but has to develop various strategies with distinct profiles and priorities, which are offered to the specific target groups. This requires a variety of programmes and instruments as well as a multitude of involved actors on all level in order to enlarge the number of perceived incentives and to amplify their impact.
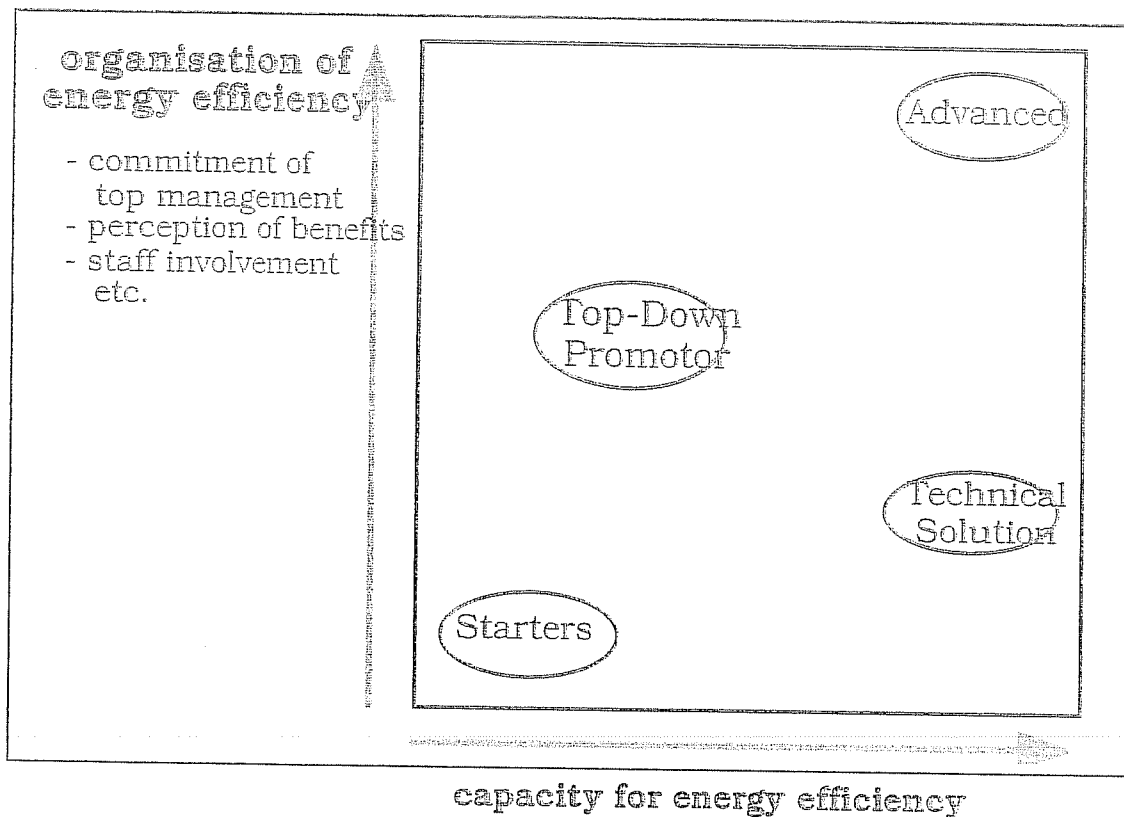
Figure 5. Four types of successful implementation of RUE measures in SME.

The SME types derived from the empirical material can be roughly characterised as:

The Advanced: These Type 1 companies give energy efficiency a high priority in all areas of action. Before they started to work with energy, they have often been "advanced" in areas other than energy (e.g. environment protection as an argument towards customers or working safety for the internal staff). Type 1 companies have built up considerable energy related experiences through continuous activities and are likely to realise new RUE measures on their own. However, they benefit from support and opportunities to continue and develop their activities. They well accept subsidies, but a high degree of free riders can be expected for companies of this type. Often their focus will be on environmental management and some are very interested in using the activities to develop their image, so that they can be motivated to participate in agreement schemes. Awards present an effective tool to give these companies the necessary publicity and to promote their realised measures. Beside stable external relations to efficiency suppliers etc., actors from these companies are often active in networks, searching for new impulses and ideas and simultaneously striving for social recognition of their successful engagement, motivating them to continue.

Type 2 is called The Top-down Promotor. Here, the result of a decision by top-management to engage in energy efficiency has not yet been transformed into technical capability. The background can be that the decision is new or that the company has difficulties in building up

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the technical capabilities. For the Type 2 companies, policy offers like energy audits or other technical assistance (training, demonstration projects) could help to turn the management's readiness into concrete action. Reliable energy service offers such as third party financing or project management are suitable to overcome internal deficiencies. The participation in regular (group) meetings with external partners indicates suitable conservation options, increases the willingness to invest in energy efficiency, and provides access to technical expertise of other firms. Best practice examples may serve as an important means to imitate successful activities. Due to the missing organisational basis of RUE measures, eco-management systems can make a valuable contribution to stabilise the engagement, and to initiate a lasting energy related learning process.

In Type 3 firms, The Technical Solution, sufficient technical capacity is available to undertake RUE projects, often due to a single actor (e.g. technical manager). In these cases top-management's commitment regarding energy efficiency is limited and the process keeps on rolling only because of the credible proposals from the engaged key actor. Top-management in these companies is rather passive in relation to energy efficiency, and probably the best way to develop the insufficient organisational dimension is a combination of a general "pressure" on the management to foster the expectation that energy and environment will become increasingly more important (e.g. by progressive taxes) and concrete positive results in the firm itself. Thus, the key actors of Type 3 companies are interested in receiving technical information and might benefit from convincing best practice examples. Additionally, subsidies for energy efficiency investments may support individual company actors to bring energy-efficient solutions on the company's agenda, but will probably not move top-management's perception of energy efficiency. Key actors benefit from technical support and personal relations by network contacts, which often serve as means to compensate their social isolation within the own firm. Due to top management's reluctance, the introduction of energy and environmental management systems is not very likely, but would address the most prevailing deficiencies in terms of an energy-efficient organisation.

Type 4 companies can be called The Starters and lack both organisational and technical know-how. This type has no direct interest in energy efficiency, realises only very evident cost-effective measures and depends strongly on external stimuli to start action (e.g. convincing energy audits through trustable external partners and clear proposal of economically feasible measures). Due to the fact, that the starter's behaviour can be characterised as imitation and adoption of existing solutions, dissemination of best practise by demonstration projects or networks helps to open the mind for feasible efficiency options. However, further incentives are needed, so that investment subsidies and taxes represent clear and simple arguments for action but have to be accompanied by further external support. Therefore, subsidies on energy audits and consulting promise to stimulate activity, which would not be undertaken otherwise.

A first estimation on the relation between the identified types of success and selected policy instruments is shown in Tab. 1. The marks indicate whether each policy instrument is likely to be accepted and to have significant impact on the realisation of energy efficiency measures in SME of this type. Within the scope of this paper, a comprehensive assessment of the particular strengths and flaws of each of the listed instrument could not be made, and of course, some of the given ratings might be point of discussion. Two general policy lessons, however, can be illustrated by the help of the derived pattern. First, it becomes clear that none of the policy measures is perfect for all types, but all measures have particular strengths concerning distinct types. Second, for all types a set of suitable instruments can be composed, calling for a well-devised differentiation of target groups and related policy mixes.

Table 1. Impact of selected policy instruments on different types of success

	1. The Advanced	2. The top-down promotor	3. The technical solution	4. The starters
Energy Audits	*	***	*	***
Subsidies for investments	*	*	**	*
Taxes (on CO_2 / energy)	**	*	***	*
EMAS / ISO 14001	**	**	*	*
(Local) Networks for information dissemination	**	***	**	**
Demonstration projects	*	**	**	**
Training/ Education (e.g. workshops)	*	**	*	*
Negotiated Agreements	**	*	*	*
Information (e.g. journals, specific technologies)	*	*	**	*

Key: *** high impact   ** medium impact   * low impact

6   A New Rationale for the Marketing, Management and Evaluation of Policy Programmes

The empirical evidence indicates the need for comprehensive and target group specific policy mixes, which cannot be discussed in greater detail in this paper. Most of the single components, such as information programmes, energy audit schemes, energy taxes, demonstration programmes, etc., are neither new nor revolutionary in and of itself. What appears to be new compared to traditional energy policy making, is a bundling of instruments to innovative policy mixes dedicated to trigger and foster implementation processes by multiple and consecutive policy intervention. In addition, more emphasis has to be given to induce energy related relations of the SME to external partners.

In this context, network formation and the stimulation energy service market relations require the design of new instruments and the interaction of policy actors with a multitude of private partners from various backgrounds—which is often an unfamiliar challenge for traditional programme administrators, grown up in a context of top-down application of measures (e.g.

enforcement of directives or taxes). At this point, the concept of social marketing[8] can make a useful contribution to develop a new participative and dynamic paradigm for energy policy-making. It provides a structure for programme design and management which is characterised by a gradual and cyclic process consisting of the phases of analysis, concept elaboration of modification (targets, programme structure and organisation, marketing mix), development and refinement of measures, implementation, evaluation and feedback (cf. Prose, 1994, Novelli, 1984). Programme management is responsible for the:

- Clear definition of the desired impact in the target group and related success criteria
- Analysis of target groups and market mechanism
- Design of actor specific ranges of instruments
- Recruitment of a wide array of cooperation partners
- Design of target group specific marketing and PR campaigns
- Establishment of supportive networks
- Evaluation and controlling of activities and programme performance

With regard to the identified internal learning loops (see. Figure 3), policy-making as well as energy service providers have to keep in mind that the target group cannot be reached in one stroke, but has to be opened gradually. Through accumulation of contacts, activity and positive experience, finally a programme can gain self-dynamic. As a consequence for the strategic policy planning, the programme should last for a sufficiently long time (e.g. 5 yrs). One or two-year programme schedules are in many cases not compatible to the general conditions of the target group (Castellow et al., 1997). If the continuity of policy is not fulfilled by using lasting programmes, but by a series of programmes, they should build on each other. In this way companies may perceive the programmes as a continued effort.

In order achieve a improving performance, policy programmes have to be built gradually and should be based on continuous evaluation and modification. Suitable start projects have to be followed by adequate monitoring and evaluation, feedback and communication of (interim) results, and measures to enforce the spread and follow-up of activities. Often neglected in programme design, extensive feedback and dissemination of positive results play an important role to encourage actors to start action and to convince others to continue.

Corresponding to programme design and management, also new requirements for policy evaluation also evolve (see Figure 6). The focus, traditionally put on the impact of a single instrument on the economic decision of an unspecified target group, has to be shifted towards the assessment of policy mixes, aiming to induce and direct energy efficiency related cooperation of various actors from distinct target groups. In this respect, traditional evaluation criteria, as for example suggested by Russel/Powell (1996), have to be interpreted in a new way. Especially the notion of dynamic efficiency—usually meant to cover technical progress—has to be enlarged and strengthened. The evaluation procedure also has to look for learning effects, long-term change of preferences, codes of conduct as well as indirect effects, which foster the implementation of RUE measures in the future. This type of impact is often connected to soft measures such as network formation, education, professional training etc., where quantitative data is hard to generate.

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[8] Social marketing is defined as "the design, implementation and control of programmes calculated to influence the acceptability of social ideas" (here: energy efficiency and environmental concern) (Kotler, Zaltman 1973). For an evaluation of successful policy programmes targeting the household sector based on the concept of social marketing, see (ISI, IfP, WI, 1997).

Furthermore, traditional evaluation tends to restrict itself on partial analyses of isolated instruments rather than trying to grasp the complex interferences caused by policy mixes. However, this evasion—motivated by methodological simplification and analytical pragmatism—incorporates the risk to fall short in explaining real and multi-instrumental world interdependencies, and thus gives inappropriate advice to energy and climate policy. The development of suitable methodologies and criteria for the assessment of policy mixes still represents a scientific challenge, and thus a promising area for energy research.
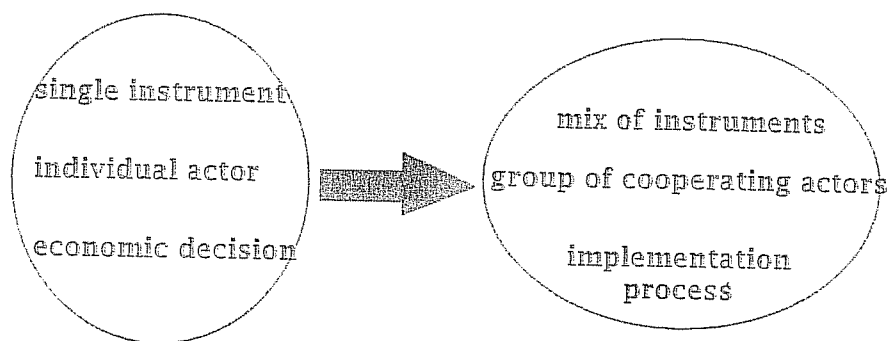
Focus of evaluation:
- dynamic concerns
- (e.g. learning, change of preferences, etc.)
- synergies & robustness of policy mix
- mobilisation capacity
- (access to target, marketing aspects.)

Figure 6. Shift of energy policy evaluation paradigms

7 Conclusion

Compared to traditional barrier analyses, the presented approach of generated a new quality of insights into implementation processes. From the view of completed realisation, it was possible to describe a broad range of influencing factors. Especially social, psychological and organisational determinants for energy efficiency implementation—which are often neglected and underestimated in their impact—can be identified and translated into policy recommendations. In addition, the analysis of positive examples allowed to study the dynamic nature of long-term success, e.g. the conditions for a development of an "energy efficiency culture" in SME, which starts with simple measures and continues with rather complex activities such as eco-management.

Rather than being a mechanical and linear enforcement of isolated instrument-impact schemes, the derived social and organisational perspective on programme implementation corresponds to a *cyclic and dynamic policy process* (see Figure 7). Effective policy-making does not only focus on economic decisions but aims to achieve a simultaneous and synergetic impact on three levels:

- overcoming of the target group's unawareness and inertia stemming from prevailing routines and low priorities of energy

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○ change of energy related routines and behaviour by internal learning and organisational changes (establishment of energy efficiency infrastructure and culture)
○ formation and support of energy efficiency networks and energy service market relations
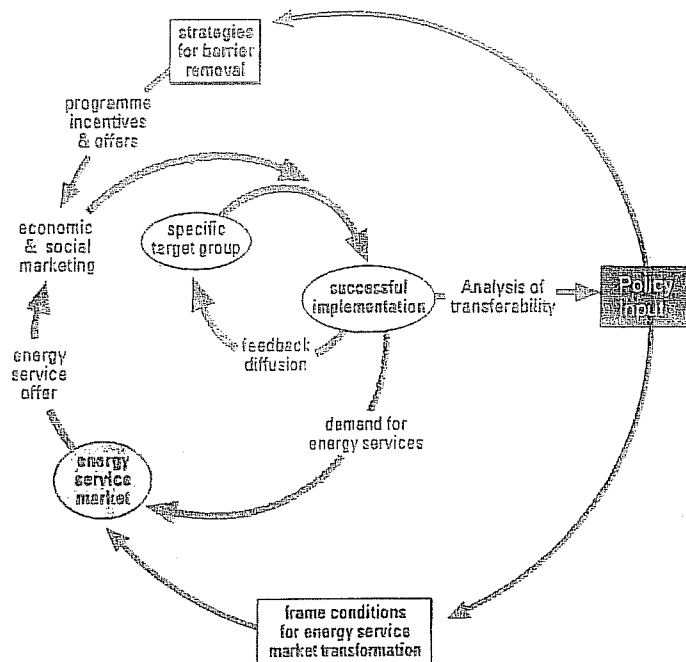
Figure 7. Cyclic and Dynamic Policy Process

This dynamic policy understanding takes into account, that the stimulation of success stories and the establishment of functioning energy service markets can hardly be achieved as an immediate effect of direct policy intervention alone (such as information programmes or investment grants). Through accumulation and re-enforcement of motivation, positive experience and efficiency expertise, and by improving general conditions for energy service actors, a wide range of positive indirect effects evolve. Hence, the focus of energy policy should no longer be on influencing economic decisions immediately, but on long-lasting attempts to improve all energy market actor's willingness and capability to decide, to act and to cooperate.

8 Acknowledgements

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Combined Generation of Heat and Power:

The Case of The Netherlands

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Abstract

The application of combined generation of heat and power (CHP) has grown strongly in the Netherlands from 1980 to present. The role of policy instruments in this process is discussed in this article.

It is shown that the growth of industrial CHP in the early eighties is partly caused by autonomous effects (energy prices) and partly by government stimulation (subsidies, low standby tariffs). In the early nineties, when the application of CHP became much broader, the positive role of the energy companies became important. This was partly also the effect of government policy (agreements with the energy companies). Furthermore, the establishment of a CHP bureau played a role.

It can be concluded that the active role of the government is to a large extent responsible for the fact that CHP has developed so much further in the Netherlands than in many other countries.

1   Introduction

Combined generation of heat and power (CHP) is one of the most important single options to save energy and reduce emissions of carbon dioxide (De Beer et al., 1996; Blok et al., 1998). The actual development of CHP strongly differs from country to country. The Netherlands is one of the countries where the application of CHP has grown to a very substantial level over the past decades and it is expected that by the year 2000 about half of the total electricity production will be covered by CHP. These facts make it interesting to consider the question of what caused this positive development. Therefore, in this article, I will investigate the importance of the role of the government and its policy instruments and the role of other actors in the stimulation of CHP in the Netherlands.

First of all, the actual development of CHP in the Netherlands will be described. Subsequently, the various policy instruments will be discussed and their influence will be estimated. This will be done for two different periods: 1978–1987 and 1987 till present. Finally, some conclusions and policy recommendations will be presented.

Combined generation of heat and power has always played a role in the Netherlands' electricity system. However, in the period after 1950, the share of CHP in total electricity production was reducing due to the fact that the total electricity production grew quickly, whereas the application of CHP was stabilising or only showed limited growth. By the end of the seventies the share of CHP in total electricity production was only about 8% (Blok et al., 1993), very similar to many other countries in Western Europe (Hendriks et al., 1996).

Since then, the application has grown steadily. In figure 1 the development of electricity production by CHP (and other private producers) is shown. In the early eighties the growth is still masked by the fact that other private generation (i.e. condensing steam turbines) declined in the same period. However, after that the development is steadily upwards. We see that in the eighties the growth is mainly in the industrial sectors. Most of the plants were combinations of gas turbines with waste heat boilers. After 1988 also CHP connected to other sectors, like greenhouse horticulture, hospitals, etc. often in the form of gas engines, becomes important, but the highest growth is still occurring in manufacturing industry (with a trend towards combined cycle plants). The fuel used for CHP is almost exclusively natural gas.
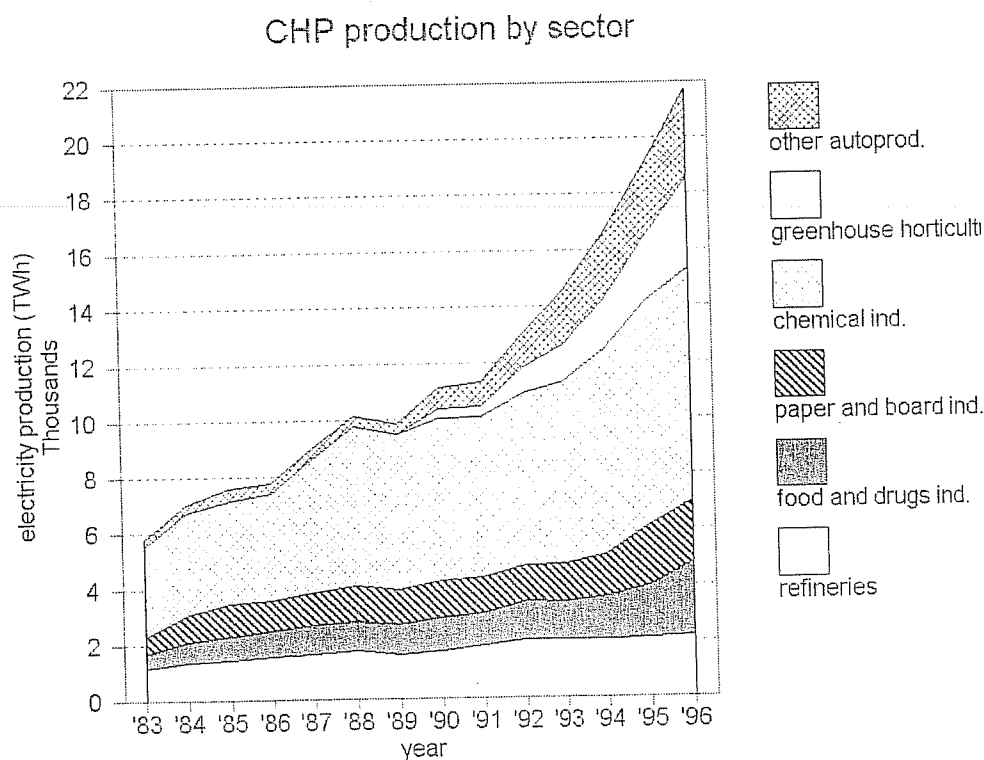
CHP production by sector

Figure 1. The Development of Combined Generation of Heat and Power in the Netherlands
Note: Private generation of electricity other than CHP (e.g. condensing steam turbines) is included, but the role is small after 1988. Data are taken from the Netherlands' national bureau of statistics (CBS, various years).

The period from 1978-1987

In the period of growth of CHP application, the following incentives were available to stimulate CHP:

- investment grants (22-32% after tax)
- investment credits
- grants for feasibility studies
- no charge for running parallel to the grid ($2/kW)
- cheap contracts for standby power ($30/kW)
- increased buy-back tariffs ($75/kW)
- delivery to other users (open grid access)
- a small R&D programme.

In an earlier publication (Blok, 1993) I have analysed the developments in detail. First of all, it should be clear that the level of energy prices in the early eighties stimulated the growth of CHP. This is illustrated in Figure 2 where the development of the pay-back-time of a 10 MWe CHP plant is depicted. Netherlands' electricity production strongly depended on natural gas, with a price connected to the oil prices. This lead to high electricity prices in the early eighties. The result is a fall of pay-back-times by typically 40% in 1981 compared to 1979. However, the resulting pay-back-times in this case of four to five years still are too long for most corporate decision makers. Note that for CHP plants larger than 10 MWe the situation is somewhat better due to scale advantages.

However, two of the above-mentioned incentives reduced pay-back-times further. The most important is an investment subsidy in the form of a corporate tax deduction scheme. The other is the offer by energy companies of contracts for standby power at a reasonable price (at least much more reasonable than in the standard contracts that were in place before that time). Both incentives together further reduced pay-back-times (see also Figure 2).

Most of the other incentives only played a minor role, which means that to a certain extent they can be considered as redundant. Special attention should be paid to the increase of the buy-back-tariffs for electricity delivered back to the public grid. Although these tariffs were increased gradually during the period we consider here, the increase came too late to have much effect and the total effect was too limited. This resulted in such a design of CHP plants that the own electricity consumption was more or less covered and delivery to the public grid could be avoided.

Special mention should be made of a government advisory body, the Committee on Industrial CHP. In fact this committee, consisting of representatives of the Ministry of Economic Affairs, energy companies and manufacturing industry, served as a negotiation panel for the CHP policy and as mechanism for the government to enforce changes required to stimulate CHP (e.g. in the area of tariffs of the energy companies).

```
Gas turbine capacity (MW)                        4        10        20
Company operation time (h/y)                  7000      8000      8760
Specific capital investment (Dfl/kW)          2370      1970      1720
Annual O&M costs (Dct/kWh)                       1.0       0.7       0.5
Electricity price increment (Dct/kWh)           4.7       4.1       3.8
Average steam consumption (ton/h)               16        40        80
Average electricity consumption (MW)             4        10        20
Symbols used                                     □         +         ◇
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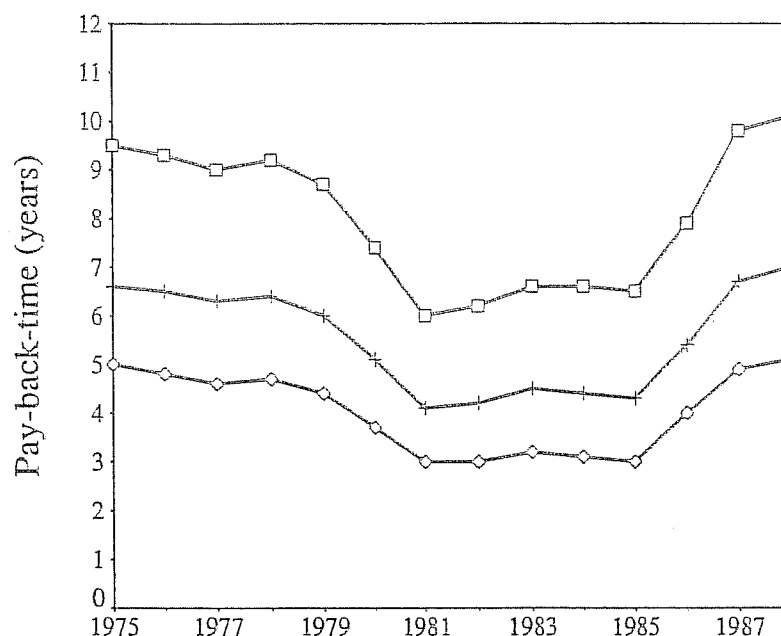

Figure 2. The pay-back-time of a 10 MW gas-turbine-CHP plant as a function of the year of investment.
Note: It is assumed that all electricity produced can be used on site. For further calculation backgrounds, see (Blok, 1993).
Legend: □ no policy intervention; ◇ including the effect of standby power contracts;
+   including the effect of both standby power contracts and investment subsidies

Note that in this period up to 1987, CHP was hardly applied outside industry. In most sectors outside manufacturing industry projects were not economically attractive. Reasons for this were the low buy-back tariffs and an unattractive gas pricing system. Furthermore, there was not much government incentive directed at these sectors. Also the interest of the energy companies to invest in CHP was low—as it was for all types of CHP in this period.

The period 1987–present

In this period the following incentives were available to stimulate CHP:

- establishment of a CHP Bureau (broker agency)
- investment subsidy for CHP (up to 25%)
- agreements with the energy distribution companies on their Environmental Action Plan
- (the Heat Plan of the energy production companies)
- long term agreements with companies in manufacturing industry.

As we can already see in Figure 2, at the energy prices prevailing in the late eighties and in the nineties, CHP in industry is not very attractive from an economic point of view (although the

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net present value may be positive on a lifecycle basis). Only for very large installations pay-back-times were in the range of three to four years. This meant that the potential for autonomous implementation for CHP in industry was fairly low (Blok and Turkenburg, 1994). Also, outside industry there was not much potential for CHP plants that were economically attractive without government intervention. Some exceptions were: large gas engine installations for hospitals and gas engines for greenhouse horticulture combined with assimilation lighting.

By the end of the eighties the activities around CHP increased again (Blok and Farla, 1996). This was due to a number of activities of which should be mentioned:

- The activities of the CHP Bureau. This office was established by the government in 1987. The mission was to stimulate the application of CHP. One of the main activities was to act as a 'broker'. This was especially important in complicated situations were many actors were involved (e.g. in greenhouse horticulture CHP projects were electricity companies, natural gas companies, and many greenhouse farmers might be involved).
- A small number of energy companies became active in investing in CHP plants.
- A new subsidy scheme for CHP.
- Long-term agreements on energy efficiency between the government and firms or business associations in manufacturing industry (application of CHP is one of the means to reach the energy efficiency targets agreed upon).

However, by far the most important contribution to the further growth of the CHP in the Netherlands came from the Environmental Action Plan of the energy distributions companies in the Netherlands. The development of this plan was started in 1989. The total plan now is directed at a CO_2 emission reduction of 17 Mtonnes in the year 2000 (compared to business-as-usual), of which more than 40% should be achieved by implementing CHP. In 1990 total installed CHP capacity in the Netherlands was approx. 2250 MWe. In the most recent version of the Environmental Action Plan a total expansion to 8000 MWe in the year 2000 is projected (EnergieNed, 1997). The Netherlands' government has stimulated the more active role of the energy companies; the responsibilities of both parties were concluded in an agreement. Furthermore, the reorganisation of the electricity sector (horizontal gas-electricity integration, vertical segregation) played a role. Due to a change in the tariff system CHP projects became more attractive from an economic viewpoint for the energy distribution companies.

Apart from the energy distribution companies, the electricity production companies also have played a role by building a number of CHP plants in the 100 MWe-plus range as part of their 'Heat Plan'. The total effect of all the activities is an even much stronger growth of CHP in the nineties than occurred in the eighties. It is hard to conceive such a development without the active participation of the energy companies. In connection to this it is important to note that ownership of CHP in the second period was different from the first period. In the period before 1987, CHP plants generally were owned by the heat consumer in manufacturing industry. After 1987 this changed: the majority of investments were done by the energy companies, or by joint ventures of energy companies and manufacturing industry.

3   Discussion, Conclusions and Recommendations

First of all, it should be noted that the conditions for a strong development of CHP were better

in the Netherlands than in many other countries. Favorable conditions include: the wide availability of natural gas in the Netherlands, the presence of some sectors with high heat requirements (refineries, greenhouse horticulture) and the absence of cheap electricity sources. However, these conditions were not sufficient to stimulate the growth of CHP: additional policy incentives were required.

The Netherlands' government has applied a large variety of policy instruments, both directed at the energy companies and at the manufacturing industry. The complete set of policy instruments turned out to be sufficient to lead to the desired CHP expansion.

Looking at the set of policy instruments, we see that some of them are redundant. It should also be clear that there is no simple solution that fits all situations: subsidy schemes may serve as an example—in the first period they played an essential role, in the second period they were just a supporting element. Also the role of the energy companies changed and became much more positive in the second period.

The stimulation of combined generation of heat and power can play an important role in policies directed at reducing the possible threat of climate change. The Netherlands' experience has shown that such stimulation can be successful. Important elements in such policies should be:

- establishment of a "broker" agency for individual projects and a negotiation body to settle national agreements on CHP
- fair access to the electricity grid, including reasonable standby tariffs and buy-back tariffs on a long-term avoided costs basis
- subsidies in an initial phase
- negotiated agreements with players that are important in relation to CHP, including the energy sector.

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U.S. Industrial Motor-Driven Systems Market Assessment

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Abstract

Over 13.5 million electric motors of 1 HP or greater convert electricity into useful work in U.S. industrial manufacturing process operations. Industry spends over $33 billion (US) annually for electricity dedicated to electric motor-driven systems. Industrial motor system electricity consumption is 24% of all U.S. electricity sold in 1994. Because nearly 70% of all electricity used in industry is consumed by some type of motor-driven system, increases in the energy efficiency of existing motor systems will lead to dramatic nationwide energy savings.

The United States Department of Energy's (DOE) Motor Challenge program is an industry/government partnership designed to help industry capture 9 billion kilowatt-hours per year of electricity savings by the year 2010. These energy savings spurred on by the Motor Challenge program will lead to a potential energy savings of 82 billion kwh/year within industry (65 in manufacturing and 17 in non-manufacturing – mining, agriculture, oil and gas extraction). This amount of energy savings:

- will increase U.S. industry's overall motor system energy efficiency by 12 percent;
- is equivalent to the amount of electricity consumed by the entire country of Venezuela for one year;
- will reduce carbon emissions by 20 MMTCE per year, which is equivalent to removing approximately 4 million cars from the road.

The main goal of the Motor Challenge program is to work in partnership with industry to increase the market penetration of energy-efficient motor-driven systems. A key element in the Motor Challenge strategy is to encourage a "systems approach" to how motors, drives and motor-driven equipment are engineered, specified, and maintained by industry. This represents a new way of looking at motor efficiency and the potential for energy and cost savings. The program focuses much of its resources on a few key industrial sectors which are participating in DOE's Industries of the Future (IOF) strategy.[1] The IOF sectors are: Forest Products, Steel, Aluminum, Metal Castings, Chemicals, Glass, Mining, and Agriculture. The Motor Challenge program also targets Water Supply and Wastewater energy savings opportunities—both industrial and municipal. The Forest Products, Steel and Mining sectors are the leading industries with which Motor Challenge is partnering to develop energy savings strategies, actions, and results. These industry partnership activities are described in this paper.

(1) The DOE Industries of the Future strategy creates partnerships between U.S. industry, government, and supporting laboratories and institutions to accelerate technology research, development, and deployment. Led by the DOE Office of Industrial Technologies within the Department of Energy's Office of Energy Efficiency and Renewable Energy, the Industries of the Future strategy is being implemented in eight energy- and waste-intensive industries: Forest Products, Steel, Aluminum, Metal Castings, Chemicals, Glass, Mining, and Agriculture.

A market assessment was commissioned by the Motor Challenge program in 1995 to better understand the characteristics of the installed population of motor systems in the manufacturing sector; to understand end user motor system purchase and maintenance practices; and to develop strategic information so that the Program could work with industry to target the best opportunities in key end use sectors.   This paper is an overview of the results of the market assessment, which lay the groundwork for a Roadmap to Energy Savings.[2]

(2) This paper presents preliminary data that will be presented in final form in a report to be released by Oak Ridge National Lab in the Fall of 1998.   Refer to the DOE Motor Challenge website with regard to the status and availability of the market assessment final report (http://www.motor.doe.gov).

1   Introduction: General Characteristics of the U.S. Industrial Motor Systems Energy Consumption

In 1994, U.S. industry consumed 691 billion kilowatt-hours of electricity in process motor-driven systems;   553 billion kwh for the manufacturing sector and 138 billion kwh for non-manufacturing (i.e., mining, agriculture, oil and gas extraction, etc.). Motors for industrial heating, ventilation, and air conditioning will add an estimated 68 billion kwh/year in motor system energy use. These motor systems were not studied as part of the market assessment.

1.1   Application Energy Distribution

As mentioned, in the US industrial sector, more than 70 percent of all electricity consumption involves motor-driven systems; of this amount of energy, 59 percent goes to some type of fluid movement or compression system, such as pumps, fans, blowers, and compressed air systems with the remaining amount going to other motor system usage (see Table 1).

Table 1. Manufacturing Motor System Energy Characteristics by Application (3)
    - PRELIMINARY DATA -

Type of Application	Motor System Electricity Consumption (10^9 kwh/year), 1994	% of Total Manufacturing Sector Motor System Energy
Pump Systems	149	27
Compressed Air Systems	100	18
Fan Systems	77	14
Material Movement/Handling	33	6
Other Material Processing	133	24
Industrial Refrigeration	33	6
Other	28	5
Total Manufacturing[2]	553	

(3) These data are for the manufacturing sector only; application data for the non-manufacturing sectors is limited, and therefore, conclusions on motor system application energy usage can not be made.

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1.2 Industry Sector Motor System Energy Distribution

Motor system energy use is highly concentrated by industry sector (see Table 2). Note that over 60 percent of motor system energy is within the top 6 sectors of which four of the six are participating the Industries of the Future initiative.

Table 2. Motor System Energy Characteristics by Industry Sector
- PRELIMINARY DATA -

Industrial Sector	Motor System Electricity Consumption (10^6 kwh/year), 1994	Industry of the Future (IOF) Sector; Motor Challenge Targeted Sector (MC)	% Total Industrial Motor System Electricity	Commutative % of Total Motor System Electricity
Chemicals & Allied Products	140,289	IOF	20.2	20.2
Paper & Allied Products	120,078	IOF, MC	17.4	37.6
Water Supply/Wastewater/ Irrigation	54,652	MC	7.9	45.5
Food Processing	51,587		7.5	53.0
Mining	39,625	IOF, MC	5.7	58.7
Steel	35,292	IOF, MC	5.2	63.9
Petroleum & Coal Products	33,750		4.9	68.8
Rubber & Misc. Plastics	32,356		4.7	73.5
Oil & Gas Extraction	29,866		4.3	77.8
Textiles	16,850		2.4	80.2
Transportation Equip.	14,908		2.2	82.4
Agriculture Production	13,452	IOF	1.9	84.3
Aluminum	11,600	IOF	1.7	86.0
Lumber & Wood Products	8,608	IOF	1.2	87.2
Glass	5,784	IOF	0.8	88.0
Metal Casting	5,268	IOF	0.8	88.8
Cement	3,012		0.4	89.2
All Other Sectors	74,286		10.8	100.0
Total	691,263			

* shaded sectors are those that Motor Challenge is initially partnering with most intensively at this time.

Industries of the Future (IOF) sectors account for comprise 53% of total industrial motor system energy consumption. The initial target sectors of Motor Challenge—Paper and Allied

Products, Steel, Mining, and Water Supply/Wastewater—account for 36% of total industrial motor system energy consumption.

1.3   Concentration of Motor System in Large Plants

Within the Industries of the Future sectors, less than 2,000 "Large Plants" (those with greater than 250 employees) account for almost 35 percent of total industrial motor system energy— see Table 3 (there are over 120,000 plants in the U.S. with greater than 20 employees). This information is leading the DOE Office of Industrial Technologies IOF and Motor Challenge program strategy to target large plants so as to have maximum impact in achieving energy-saving results in the near and long term. The larger plants will serve as Showcase examples for other plants in industry to replicate the success stories developed.

Table 3. Motor System Energy Concentrated in "Large Plants", Industries of the Future Sectors
- PRELIMINARY DATA -

Industry Sector	Motor System Electricity Consumption in Large Plants (10^6 kwh/year), 1994	# of Large Plants	Average Motor System Electricity Consumption per Large Plant (10^6 kwh/year)	% Total Industrial Motor System Energy for Large Plants in Sector
Chemical & Allied Products	95,487	846	112.9	13.8
Paper & Allied Products	85,906	255	336.9	12.4
Mining	17,735	185	95.9	2.6
Steel	24,680	197	125.3	3.6
Agriculture	NA	NA	NA	NA
Aluminum	8,111	100	81.1	1.2
Glass	5,768	188	30.7	0.8
Metal Casting	3,684	200	18.4	0.5
Total Industries of the Future "Large Plants"	241,171	1,971	122.4	34.9
Total Industry	691,263			

2   Moving Towards a Systems-Oriented Solutions

2.1   Evidence the Market is Changing

In the early to mid 1990s, the majority of public and private-sector efforts to improve motor system energy efficiency focused on the motor, rather than other individual motor-driven system components or, more importantly, on the system as a whole. There is evidence in the past two to four years, however, that change is occurring in the market, as influenced by both private and public sector activities to focus more on system-based solutions. Examples of these activities, include:

➢ People are talking about systems more. Although hard to measure, people, in general, are talking about, and are more focused on motor system opportunities then just on motor efficiency opportunities.

➢ Training curriculum has been developed by the Energy Center of Wisconsin, the Hydraulic Institute, and Motor Challenge that educates industry on fluid system optimization principles—pump and fan systems training.

➢ Motor Challenge tools, such as MotorMaster+ and other technical information are being used by thousands of people as provided directly by Motor Challenge, or by the 170 Motor Challenge Allied Partners that disseminate Motor Challenge information with the support of the Program (Allied Partners are non end users, such as original equipment manufacturers, distributors, utilities, State energy agencies, engineering firms, etc.). Likewise, MotorMaster+ software has been greatly upgraded to help the user to analyze system effects when installing a new motor (e.g. putting an energy-efficient motor on a centrifugal load).

➢ The Compressed Air Challenge has been developed recently as a result of Motor Challenge efforts to unite participants in the compressed air system market. The Compressed Air Challenge is looking at all varieties of opportunities to improve compressed air system efficiency, and are developing information and training curriculum to support plant operation staff to target these opportunities.

➢ The Electric Power Research Institute (EPRI) has developed the software program called ASDMaster. ASDMaster helps a person designing and purchasing an electronic AC adjustable speed drive to choose and specify the best ASD for their application. System effects are analyzed with the program.

➢ Motor Challenge Showcase Demonstrations are proving that system energy savings opportunities are tremendous and average around 30 percent (see section later in this paper).

➢ Companies such as 3M, Dupont, Johnson & Johnson are promoting system-based solutions within their companies.

2.2 The Systems Approach

A "systems approach" seeks to increase the efficiency of electric motor systems by shifting the focus from individual components and functions to total system performance (see Figure 1). When applying the systems approach process system design and manufacturing best practices seek to optimize performance in the entire process system, and then on selecting components and control strategies, which best match the new, reduced process load. The steps involved in accomplishing a system optimization would involve: characterizing the process load requirements; minimizing distribution losses; matching the driven equipment to load requirements; controlling the process load in the most optimal manner considering all cycles of the process load; and properly matching the motor and drive to each other as well as the load.
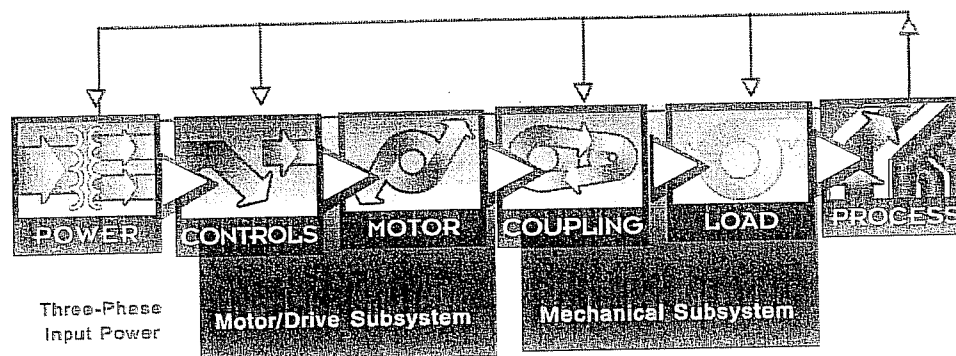
Process Mechanical and Electrical Feedback

Figure 1. Motor System Diagram

2.3 Motor Challenge is Demonstrating the System Approach Pays

Motor Challenge *Showcase Demonstration* case studies provide examples of how companies have undertaken improvements in their electric motor systems and have benefited from verified energy savings and related improvements in waste reduction and productivity. DOE has sought Motor Challenge industry partners who are willing to participate as Showcase Demonstrations. In exchange for technical assistance and the opportunity to try out new technologies, Showcase participants must be willing to undertake detailed monitoring and analysis that will help all other industry partners understand how to make their operations run better. To date, 13 Showcases have been completed and have saved in aggregate $2.2 million US at an average payback of approximately 1.5 years (see Table 4). Even more impressive is the average system efficiency improvement of 33% for all 13 projects. These Showcase examples prove that there are large opportunities available to industry with efficient motor systems. Additionally, the case studies generated from these projects are in large demand by trade magazines for publication; by Motor Challenge Allied Partners (suppliers, utilities, distributors, engineering firms, etc.); and by industry end users.

2.4 Motor and Motor System Energy Savings

The market assessment estimated energy savings that are economic (less than three-year payback). Only savings in the industrial sector were estimated. The results below do not include improvements to commercial building motor system applications. There were three areas of savings analysis:

➢ New energy-efficient motor purchases – Energy savings from the purchase of new energy efficient driven by both the new Energy Policy Act (EPACT) motor regulation and purchases of energy-efficient motors for applications that are not covered by EPACT.

➢ Improved motor management practices – Energy savings from better management of currently installed motors with improved repair practices, more properly matching motor size to the driven load, and the adoption of motor management best practices.

➢ Improved motor system optimization – Energy savings from overall system optimization from better matching fluid handling devices (e.g. pumps) to the load, and

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implementing more optimal control strategies and technologies (adjustable speed drives) to accommodate fluctuating loads.

Table 4. Motor Challenge Showcase Demonstration Results

Showcase Demo Company Site	Type of Plant	Energy Savings kWh/Year	System Savings, %	Annual Cost Savings, $US	Payback on Investment, Years
General Dynamics	Metal Fabrication, Metal Plating	451,778	38	$68,000	1.5
3M Company	Laboratory Facility	10,821,000	6	$823,000	1.9
Peabody Coal	Coal Processing	103,826	20	$6,230	2.5
Strohs Brewing	Beer brewing	473,000	52	$19,000	0.1
City of Milford	Municipal sewage pumping	36,096	17	$2,960	5.4
Louisiana-Pacific	Strand board	2,431,800	50	$85,100	1.0
City of Trumbull	Municipal sewage pumping	31,875	44	$2,614	4.6
Nisshinbo California	Textiles	1,600,000	59	$100,954	1.3
Greenville Tubing	Stainless steel tube fabrication	148,847	34	$77,266	0.5
Alumax	Primary aluminum production	3,350,000	12	$103,736	0.0
OXY-USA	Oil field pumping	54,312	12	$5,362	0.5
City of Long Beach	Municipal waste incineration	3,661,200	34	$329,508	0.8
Bethlehem Steel	Fan system on basic oxygen furnace	15,500,000	50	$542,600	2.1
Total/ Average		38,663,734	33	$2,166,330	1.5

2.5   Energy Savings from New Energy-efficient Motor Purchases

As of October, 1997, the Energy Policy Act of 1992 motor regulation (EPACT) requires that general purpose, polyphase, single speed, squirrel-cage induction motors manufactured for sale in the US and rated from 1-200 HP meet minimum efficiency standards. In addition to these standards, EPACT also requires standardized testing procedures and labeling. (EPACT does not require users of motors to replace currently installed standard efficient motors with energy-efficient models, but rather only requires the purchase of some categories of new motors to be

energy efficient). Table 5 shows the projected energy savings from motors covered by EPACT(1 to 200HP); the incremental energy savings when EPACT motors are upgraded to higher efficiencies suggested by the Consortium for Energy Efficiency levels (above EPACT levels); and the energy savings for upgrading motors not covered by EPACT that are above 200HP. These energy savings do not include the savings available from energy-efficient motor upgrades in commercial building facility applications.

Table 5. Savings from New Energy-efficient Motor Purchases for the U.S. Manufacturing Sector

	Energy Savings (10^6 kwh/year)	% Total Manufacturing Motor System Energy Savings
Savings from upgrading motors covered by EPACT to EPACT level efficiencies	7,286	11.1
Savings from upgrading motors covered by EPACT beyond EPACT efficiencies to CEE level efficiencies	4,303	6.5
Savings from upgrading motors not covered by EPACT (greater than 200 HP) to maximum efficiency levels currently available	4,579	7.0
Total Savings	16,168	24.6

2.6 Improved Motor Management Practices

Table 6 shows the energy savings from improved motor management practices and systems within the manufacturing plant.

Table 6. Savings from Improved Motor Management Practices for the U.S. Manufacturing Sector

	Energy Savings (10^6 kwh/year)	% Total Manufacturing Motor System Energy Savings
Savings from improved motor repair and rewind practices	1,001	1.5
Savings from improved sizing and design of motors and drives to each other and the applied driven load	5,000	7.6
Total Savings	6,001	9.1

2.7 Improved Motor System Optimization

Table 7 shows the savings from optimizing motor systems using a systems approach.

Table 7. Savings from Improved Motor System Optimization for the U.S. Manufacturing Sector
- PRELIMINARY DATA -

Motor System Energy-saving Area	Energy Savings (10^6 kwh/year)	% Total Manufacturing Motor System Energy Savings
Savings from improved pump system optimization	10,838	16.5
Savings from improved pump system control (including ASDs)	10,838	16.5
Savings from improved fan system optimization	3,245	4.9
Savings from improved fan system control (including ASDs)	1,857	2.8
Savings from improved compressed air system optimization	7,644	11.8
Savings from improved compressed air system control (including ASDs)	1,911	2.9
Savings from optimization and better control of non-fluid systems (e.g. material handling, movement and processing devices)	7,207	11.0
Total Savings	43,540	66.3

As Figure 2 shows two-thirds of the manufacturing motor system savings are system related, demonstrating that management decisions and technical actions that support a systems approach at the corporate and plant level will be the key to achieving large scale energy efficiency improvement in manufacturing motor systems.
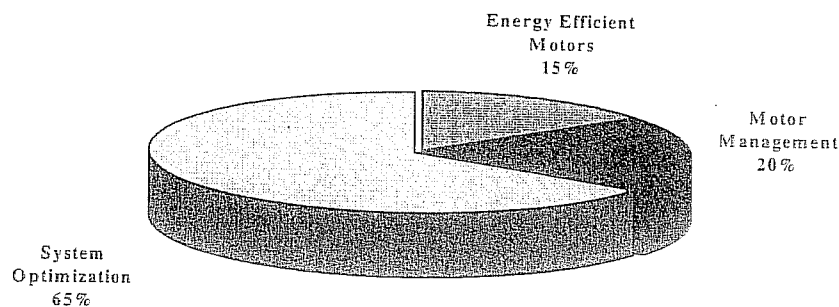

Figure 2. Breakout of Manufacturing Motor System Savings

2.8 Targeting the Opportunities

As mentioned, Motor Challenge is targeting the industry sectors of Forest Products (especially pulp and paper), Steel, Mining, and Water Supply/Wastewater. Figures 3 and 4 show the potential energy savings within the pulp and paper and steel industries, respectively. Medium to large-sized pump systems are the prime opportunity in pulp and paper, whereas large fan and compressed air systems are the target within the steel industry.
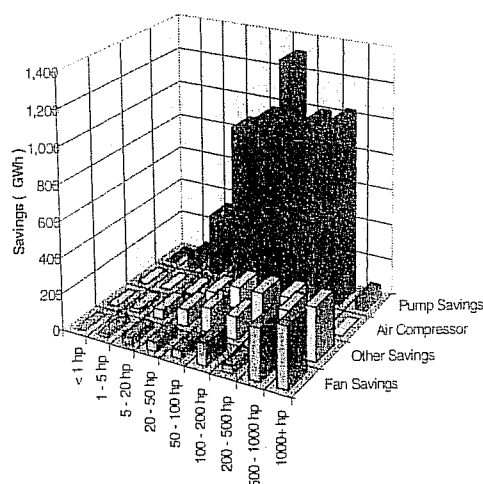

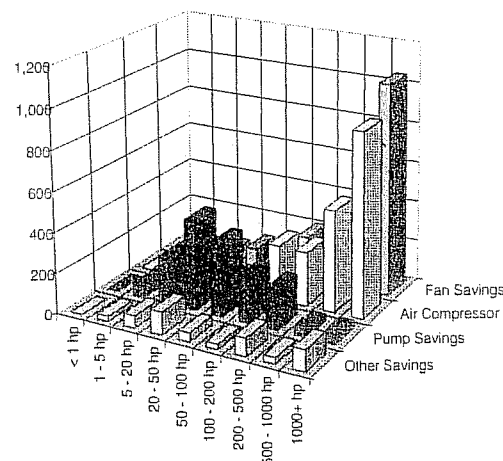Figure 3. Pulp and paper industry motor system savings (Million kwh/year)

Figure 4. Steel industry motor system savings (Million kwh/year)

3 Key Motor Challenge Industry Partnerships

Motor Challenge relies on working within the established industry channels to develop strategies that will most effectively influence the industrial end users at a variety of decision-making levels. The following are summaries of key Motor Challenge industry partnerships:

Pulp and Paper: TAPPI is the technical professional society of the pulp and paper industry. As a Motor Challenge Allied Partner TAPPI lends credibility to Motor Challenge's standing with pulp and paper company's technical staff. Even more importantly, TAPPI provides a great deal of leverage for the Motor Challenge. TAPPI is the world's largest technical association for individuals and companies in the paper, packaging, converting and related industries, with more than 33,000 members in over 70 countries (most members are in the U.S.). Motor Challenge products are being distributed by TAPPI to members, and joint training sessions on motor management, adjustable speed drives, and pump system optimization have already been conducted or are being planned.

Steel: DOE–OIT and Motor Challenge have begun to work with the Association of Iron and Steel Engineers (AISE). Efforts will begin to develop a partnership similar to the TAPPI/Motor Challenge partnership to deliver technical information and training through the AISE organization. Likewise, the American Iron and Steel Institute (AISI) has a long-standing partnership with OIT in the area of advanced steel making technology development.

Mining: Recently, the National Mining Association (NMA) became the eighth industry sector to partner with OIT in the Industries of the Future initiative. NMA will become a Motor Challenge Allied Partner. A strategy will be developed with NMA to deploy energy-efficient motor system technology and information to the U.S. mining industry.

Water Supply/Wastewater: Working with a variety of organizations, including the American Water Works Association (AWWA), Motor Challenge has targeted this motor system intensive industry. Over the past two years, a training workshop series focusing both on motor management and pump system optimization principles has been deployed in a variety of States in the U.S (e.g. California and New York). All training sessions have been very highly attended and have been well received. AWWA regional chapters are now being targeted as a mechanism to get broader replication of the education curriculum developed and deployed.

4 Conclusions: Putting the Whole Strategy Together and Moving Forward

Showing the overall value of motor system efficiency to the key industries, along with developing the overall outreach strategy in unison with these sectors will be the key achieving results. Motor Challenge is currently developing a plan that will both complement the IOF R&D portfolio being developed and that meets the needs of any individual industry or company. A multi-step approach is being developed by Motor Challenge with industry with the following elements:

➤ instituting a cooperative training and communications program with an industry that helps plant people become more proficient in the use of new tools and best practices; articles will be developed to reach a broad audience; industry groups will be networked to develop mutual interests (e.g. link the pulp and paper industry (TAPPI) to the pump industry (Hydraulic Institute)).

➤ develop more industry specific showcase demonstrations; work with groups such as TAPPI to develop benchmarking information so that plant operators can determine the best opportunities in their respective pulp and paper mills.

➤ develop and provide easy access to pertinent information specific to an industry.

➤ undertaking marketing campaigns with original equipment manufacturers, suppliers, distributors, and end users to increase attention to the opportunities—at all levels from plant operations staff to CEOs.

➤ provide recognition to the people that are getting results with awards, and articles and communication about these people through various media.

Most importantly, Motor Challenge will develop its strategy so as to add value to the Industries of the Future portfolio of emerging technology, technical information and tools so assist U.S. industry to be more energy efficient and competitive with reduced emissions and waste released to the environment.

Appendix A: Program Workshop
THURSDAY, JUNE 11, 1998

9:00   Welcome
        Steve Morgan, European Commission–DG–XII
9:15   Introduction, Background and Goals of the Workshop ("Beyond Indicators")
        Ernst Worrell, Utrecht University/Lawrence Berkeley National Laboratory

Evaluation and Assessment of Policies and Policy Instruments

Financial Instruments
9:45   Energy Conservation Investments of Firms: Evaluation of the Energy Bonus in the
        Netherlands in the 1980's
        Jacco Farla, Utrecht University, The Netherlands
10:15   Evaluation of the Danish CO_2 Taxes and Agreements
        Mikael Togeby, AKF, Denmark

10:45-11:00   Break

Voluntary Agreements
11:00   Evaluation of Energy-Related Voluntary Agreements
        John Newman, International Energy Agency, France
11:30   Quantitative Evaluation of Voluntary Agreements on Energy
        Efficiency
        Martijn Rietbergen, Utrecht University, The Netherlands
12:00   Long Term Agreements on Energy Efficiency in Industry
        Wil Nuijen, NOVEM, The Netherlands

12:30   Discussion
13:00   Lunch

Information, Monitoring and RD&D Programmes
14:00   Evaluation of the Former EADC Program
        Michael Muller, Rutgers University, USA
14:30   Norwegian Industry's Network for Energy Conservation
        Per Finden, IFE, Norway
15:00   The UK Energy Efficiency Best Practice Program: Evaluation Methods and Impact,
        1989-1998
        Diana Goult, ETSU, UK

15:30-15:45   Break

Experiences in Non-OECD Countries:
15:45   Russian Industry: Paving Road to Rationality
        Igor Bashmokov, CENEf, Russia
16:15   Industrial Electricity Efficiency Programs in Brazil
        Roberto Schaeffer, Federal University of Rio de Janiero, Brazil
16:45   Industrial Energy Efficiency Programs in India
        Prosanto Pal, TERI, India

17:15   Discussion on lessons learned and methods used

FRIDAY, JUNE 12, 1998

Evaluating Across Instruments and Integrated Policies

Presentation on Integrated Policies
09:00   Overview of Industrial DSM Programmes
              Anibal de Almeida, University of Coimbra, Portugal
09:30   EU Energy Efficiency Policy on Industrial Energy Use
              Line Hagen, European Commissions–DG-XVII
10:00   Successful Implementation of Energy Efficiency in Light Industry: A Socio-economic
              Approach to Industrial Energy Policies
              Stephan Ramesohl, Wupperstal Institut, Germany

Presentations on Technology-oriented Policies
10:30   Combined Generation of Heat and Power: The Case of The Netherlands
              Kornelis Blok, Utrecht University
11:00   U.S. Industrial Motor-Driven Systems Market Assessment
              Paul Scheihing, US DOE–OIT

11:30-13:00   Break-out sessions for discussion
Discussing the problems of analysing the effects and effectiveness of industrial policies.

13:00-14:00   Break

14:00   Methodology Development and Collaboration
What did we learn these two days? What is needed? How to proceed?

15:30   Setting a research and policy agenda for future collaboration in industrial energy
              policy
              Wolfgang Eichhammer, FhG–ISI, Germany
16:30   Conclusions: Trying to Understand the Barriers and Opportunities
              Ernst Worrell, LBNL/Utrecht University

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